Instruments

THE MAGAZINE OF Measurement and Control

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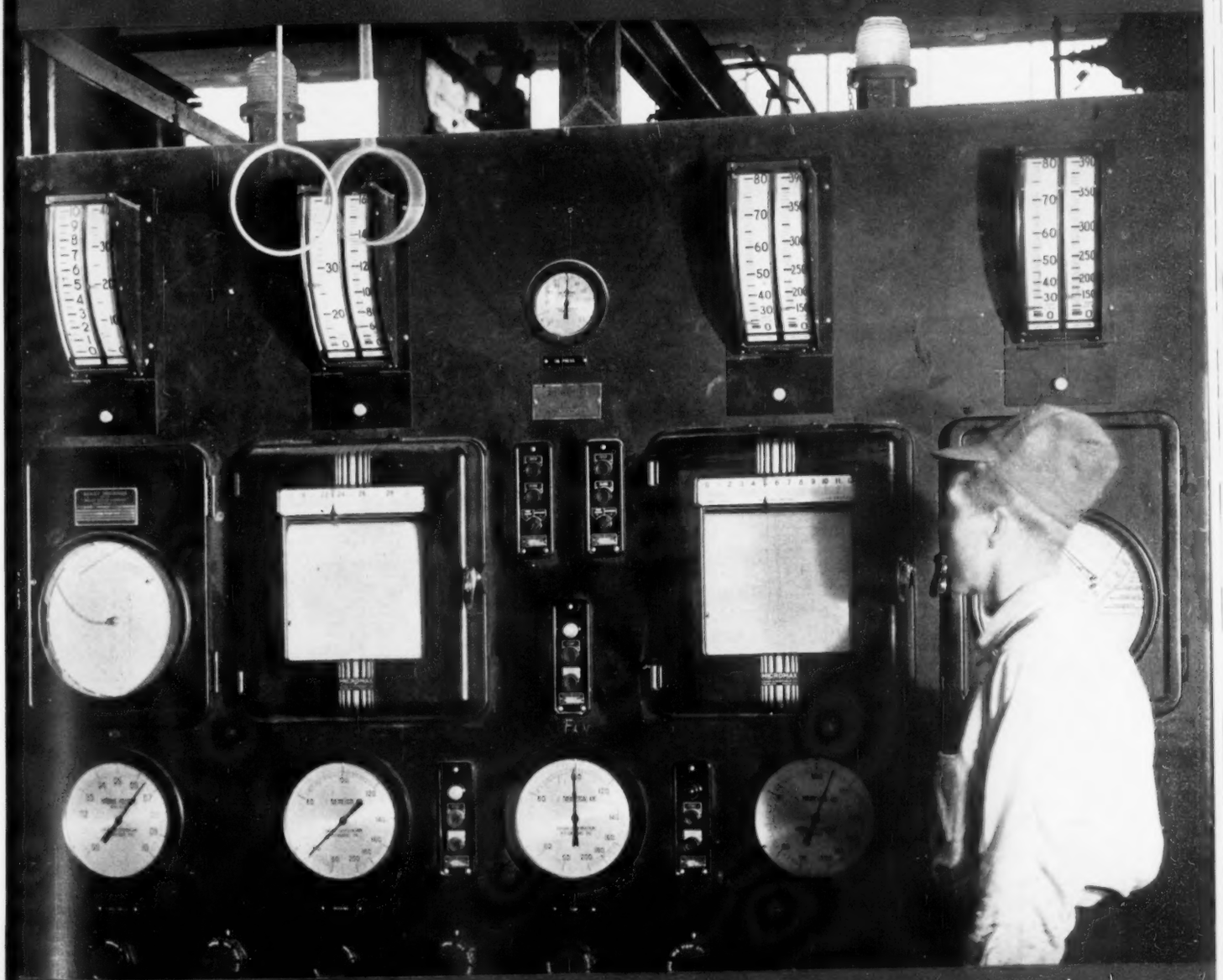
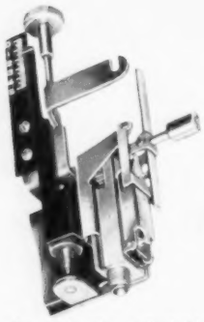
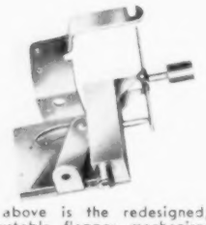
No. 11



Guarding Product Quality with Precise Indicating Control



Shown above is the adjustable, calibrated flapper mechanism. Its design permits easy adjustment of throttling range to coincide with great apparatus lag.



Shown above is the redesigned, non-adjustable flapper mechanism in its simplest form . . . the ideal pilot for a great majority of control applications.

A COMPLETE LINE OF TAG INDICATING CONTROLLERS . . . "ON-OFF" AND THROTTLING MODELS

In guarding quality and maintaining product uniformity by dependable supervision of temperatures, TAG has long been a by-word in process control. The Indicating Controller was designed not only for real operating convenience, but also to cope with stiff plant conditions. The entire line of TAG Indicating Controllers is now presented in moisture-proof, aluminum cases—beautifully finished in black enamel with chromium trim.

All the latest TAG developments plus the sound principles and approved standards long present in TAG Air-Operated Control are to be found in these reliable instruments. There's a Bulletin No. 1175-1 which describes both the "ON-OFF" and Throttling Models . . . it will tell you what you want to know about them.

C. J. TAGLIABUE MFG. CO.

Park & Nostrand Ave's., Brooklyn, N. Y.

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How Long Since You Checked on RECORDING THERMOMETERS?

Today's conditions call for a new review of the profit-insurance possibilities of these simpler, surer, *mono-therm* instruments.

Was your last analysis of the possibilities for saving money with Recording Thermometers made back in the days when capital outlays were "out"? Did you decide to "let things ride for awhile," knowing that the addition of recording thermometers at one or more points would actually be a sound investment once profits were in sight again?

In that case, now's the time to recheck the situation in the light of rising costs of raw materials and the consequent higher costs of waste and operating delays. What's more, Foxboro's modern mono-therm system adds new factors of simplicity, surety and rapid response to the "go-ahead" side of the investment equation. You get the accurate records you need, day in and day out, without pampering or service expense. Today, on a unit-of-production basis, accurate temperature records are a cheaper form of profit-insurance than ever before!

Why not call in your superintendent and check over those trouble-spots that a few good, responsive Temperature Recorders might eliminate once and for all? The Foxboro man in your locality can suggest the particular type that will give you the records you want, and pay for itself most quickly out of its own savings. Or, if you wish, we'll mail you a 40-page bulletin, "Recording Thermometers," that gives facts and figures you're bound to need. Write for it today. **The Foxboro Company, 46 Neponset Avenue, Foxboro, Massachusetts, U. S. A.** Branch offices in 25 principal cities.

There are FOXBORO Recording Thermometers To Meet Every Need

Vapor Pressure — (Class II) The thermal system is filled with a vapor and a volatile liquid. It has the fastest response of any type.
Range: −25° F. to +650° F.; maximum length of tubing 300 ft.; minimum bulb size ⅜ in. x 2½ in. or ⅜ in. x 4 in.

Gas Pressure — (Class III) The thermal system is filled with an inert gas. A rugged yet inexpensive unit for wide-range service.
Range: −60° F. to +1000° F.; maximum length of tubing 500 ft.; minimum bulb size ⅞ in. x 6 in. or ¾ in. x 10 in.

Liquid Expansion — (Class I—Compensated for ambient temperature at case. Class IV—Fully compensated for ambient temperature) The thermal system is filled with a special expansible liquid.
Range: −150° F. to +500° F. Maximum length of tubing: Class I — 25 ft.; Class IV — 150 ft. Minimum bulb size ⅜ in. x 1 in.

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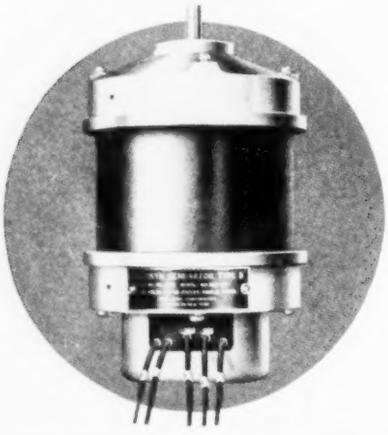
Instruments
Certified ACCURACY RESPONSE
TEMPERATURE · LIQUID LEVEL
PRESSURE · FLOW · HUMIDITY

What good is Remote Reading unless you can rely on it?



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SELF-SYNCHRONIZING

MOTORS

afford thoroughly reliable remote instrument indication and control

The circuit diagram above shows how simply Bendix-Cory Autosyn Motors provide sensitive, reliable remote readings of many varied types of instruments, as well as remote actuation of light-load controls. One transmitter and one receiver motor or one transmitter motor and several variously located receivers may be used.

Features of Autosyn Type B (Illustrated)

1. Guaranteed accuracy of one degree plus or minus. Specially selected motors may be held to an accuracy of ½ degree, plus or minus.
2. Maximum torque of 72 inch ounces at 115° angular displacement.
3. Safe continuous operating torque—17 inch ounces.
4. Collector Rings are made of hard drawn fine silver.
5. Brushes are made of annealed fine silver.
6. Brushes carry no current during synchronism.
7. Interchangeable with most commercial flange-mounted motors.
8. Dimensions 7-3/16" x 4½".
9. Weight, 11 lbs.
10. Low current consumption and heating characteristics.

BENDIX AVIATION CORPORATION

MARINE DIVISION

754 LEXINGTON AVE., BROOKLYN, N. Y.

Instruments

THE MAGAZINE OF MEASUREMENT and CONTROL

Vol. 12 No. 11

NOVEMBER 1939

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Instruments THE MAGAZINE OF *Measurement and Control*

M. F. Béhar, Editor

Consult the Man Who Knows

FIRST of all, your editor desires to thank all those who were so kind to him during the thirteen weeks that pneumonia, coronary thrombosis and vascular complications kept him away from his desk. It is only lately—by putting two and two together—that I have been able to discover proofs of sublime friendship which were meant to be secret—including some instances of self-sacrifice. I am strongly tempted to name those "friends in need: friends indeed," but this natural impulse must be resisted. Such publicity might make it appear that some well-doers were partly motivated by a desire for publicity—whereas all were unselfish. Furthermore, it is worthier of them to use this page for constructive suggestions—its normal mission. The most helpful suggestion which comes to mind as a result of recent experiences is to draw a parallel between the health of an industrial plant and the health of an individual.

I nearly lost my life because "half knowledge is worse than no knowledge." The doctor had advised that I go to a hospital for a thorough examination—X-ray photos, blood tests, etc.—followed by scientific treatment. But I kept working. So, instead of going to the hospital I had to be carried there! Please do not be offended, dear reader, if it is respectfully suggested that decisions involving process instrumentation should not be made hastily. The need should be clearly diagnosed—by a specialist. The correct class and type of device should be selected—by a specialist. It should be properly installed—by a specialist. And so on.

Some individuals possess such a fund of modern scientific information about that complicated organism, the human body (more complicated than the largest factory) and about all pathogenic bacteria and viruses, that they can doctor themselves: they are equipped to recognize the incipience of any disease, to diagnose it and prescribe the optimum treatment. Such individuals are rare. Even physicians usually consult other physicians.

Some industrial plants are blessed with the services of so many different specialists that there is little need to go outside the organization when problems come up involving measurement and control of operations and processes. Such organizations, however, are few.

Perhaps the most insidious danger involved in "self-doctoring" in an industrial plant is the waste of time and effort involved in "inventing" an instrument—from the simplest gadget to the most elaborate telemetering or automatic-control system—when the members of the organization, in spite of their impressive total knowledge, are not aware that such a device is commercially available.

Almost as common as the man who doesn't listen to the doctor is the man who thinks that his plant or department or process is completely instrumentized. Professor C. C. Furnas is right in declaring that "the intriguing and labor-saving devices that magazine articles feature are unusual or they would not be there. Every industry in the country is permeated with obsolete equipment and methods of production."

For every problem in process control there is one best solution in the form of an appropriate instrument or system. In the majority of cases this optimum instrument or system has already been invented.

Even more important is it to keep in mind that for every situation involving a problem, there is a best way of *going about seeking the best solution*. Never does this one best way of seeking a solution consist in leaving it to whoever happens to be immediately concerned—for example, the operator of a machine. Seldom does the best procedure consist in leaving the final decision to the operator and to his immediate superior in the production department. A much better procedure is for the operating personnel to get in touch with someone in the Process Research department or whichever department is concerned with fundamental engineering problems: such a department, serving the various production departments, makes it its business to be prepared with solutions. Human memory being limited, efficient preparation involves a technical library constantly kept up to date by the receipt of the current technical magazines and the latest literature of manufacturers of the devices for which the plant may have a need. Of great usefulness, likewise, are the "Where to Find It" and "Who Makes What" services maintained by technical magazines.

After all, since there are more than 800 manufacturers of instruments, meters and control systems, the chances are that you will never have to "build your own."

You are invited to attend a meeting of the

AMERICAN SOCIETY FOR MEASUREMENT AND CONTROL

(formerly American Society of Instrument Engineers)

at the Bureau of Mines Auditorium, Pittsburgh

MONDAY, NOV. 20, 7:30 P. M.

Prominent speakers will address the meeting

For later details write to

FRANK C. McGOUGH, 3 BUFFALO ST., PITTSBURGH

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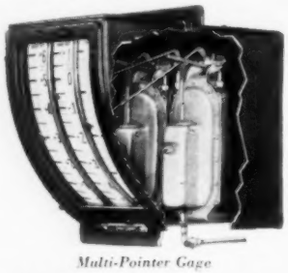
METERS and CONTROL *for Boiler Room Service . . .*

Boiler Meters Indicate, record and integrate Steam Flow from the boiler, record Air Flow supplied for combustion and record Flue Gas Temperature. The use of this meter reduces fuel cost, lessens maintenance and outage, lowers standby costs, and adds capacity.

Bailey Boiler Meter

Multi-Pointer Gages for indicating drafts, pressures, differentials are available with any number of pointers from one to twelve. They are actuated by sturdy yet sensitive diaphragm units.



Multi-Pointer Gage

Flow Meters. For indicating, recording and integrating the flow of steam, feed water, compressed air and other fluids.

Coal Meter

Granular Material Meters For accurately measuring the flow of coal or other granular materials in gravity chutes from overhead bunkers. The total quantity of granular material is shown on a large illuminated counter which may be easily read at a distance of 50 feet.

Control Systems. Make possible the everyday operation of equipment for steam generation and utilization at test efficiencies. They are applied to the control of combustion, feed water, superheat, desuperheat and other factors.

Complete Information on any of the above Bailey products will be gladly furnished upon request.

G-7

BAILEY METER COMPANY

1041 Ivanhoe Rd., Cleveland, Ohio

The MONTH'S NEW INSTRUMENTS

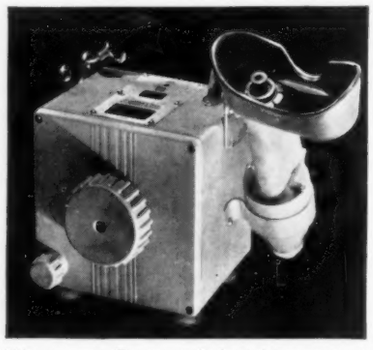
In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

Or write to Information Section, Instruments Publishing Company.

Optical Pyrometer Utilizing Potentiometric Method

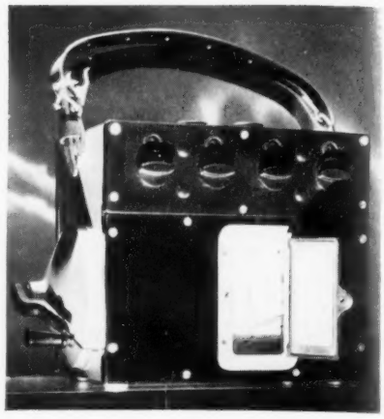
New L&N Optical Pyrometer is not a redesign of a previous model but a fundamentally new design. It is a new type of temperature measuring instrument, being the first industrial optical pyrometer to use the potentiometric method. It is calibrated directly in degrees of temperature, not in



milliamperes. To meet industrial pyrometry requirements it has been made light in weight and rapidly operable but is said to be also amply accurate for laboratory use.—*Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.*

Power Factor Oil Cell

New "No. 167" Davidson oil cell requires only 10 ml. for a power factor determination. High-voltage electrode, measuring electrode, and guard electrode are solid nickel which has been found inert with transformer and cable oils and minimizes likelihood of erratic performance. There is a self-contained heater for heating the cell. A bakelized-linen bushing spaces and insulates the measuring electrode, and a similar bushing locates and insulates this assembly from the high-voltage cup. Complete assembly of measuring, guard, and high-voltage electrodes is suspended in an air bath from the bakelized-linen top of the heater cup which can set as a grounded shield to the complete assembly. Design follows quite closely one developed by Dr. Ward F. Davidson of Consolidated Edison Co.—*Mico Instrument Co., 10 Arrow St., Cambridge, Mass.*



"MEGGER" INSULATION TESTERS

HAND GENERATORS UP TO 5000 VOLTS D.C.
RANGES UP TO 20,000 MEGOHMS

Designed for maximum convenience, portability and ruggedness for testing insulation resistance of all types of electrical equipment. A comprehensive assortment of types and ratings is described and illustrated in our Catalog 1550-I. Write for a copy.

Illustration shows our "Bridge-Meg" Resistance Tester—a combined "Megger" Insulation Tester and Wheatstone Bridge.

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ELECTRICAL AND SCIENTIFIC INSTRUMENTS
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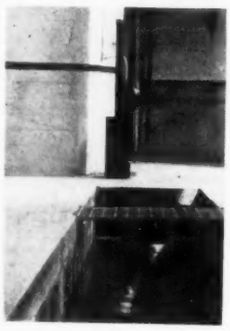
Accurate Measurement Through WEIRS . . . *at Lackawanna, N. Y.*



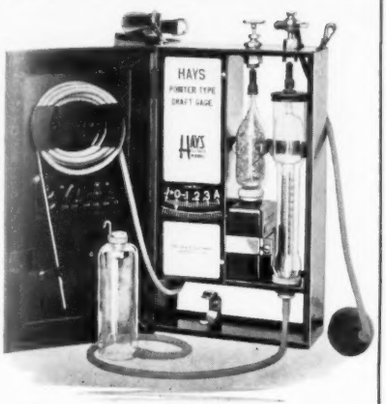
At the Wilmuth St. Station in Lackawanna, N. Y., a Cochrane Electric Flow Meter is installed to total sewage passing through the hyperbolic weirs in two separate flow channels. A tribute to the precision of Cochrane instruments is the accuracy with which flow is recorded, as normal flow must be recorded on a short radius to permit charting of occasional abnormally high flows due to sudden rainstorms or other causes. Write for further information.

ABOVE: *Cochrane Transmitter mounted at one of the two hyperbolic weir channels.*

COCHRANE CORP., 3120 N. 17th St., Phila., Pa.

COCHRANE
FLOW METERS

A LABORATORY JOB DONE IN THE FIELD



HAYS PORTABLE COMBUSTION TEST SETS are equipped to handle an accurate gas analysis—right in the field.

Installations become more successful, trouble-makers are rapidly exposed, guesswork becomes a thing of the past.

Test Sets are available with all necessary equipment for the analysis for CO_2, CO, and O_2—complete with flue gas thermometer, and draft gage. For further particulars—write to 925 Eighth Avenue, Michigan City, Indiana.

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COMBUSTION INSTRUMENTS AND CONTROLS
MICHIGAN CITY, INDIANA, U.S.A.

DON'T LET FAULTY DRAFT RUN-UP STEAM COSTS

MAINTAINING PROPER DRAFT is relatively a simple job once a Hays Draft Gage has been installed. Accurate measurements supplant guesswork, resulting in more efficient combustion.

HAYS ORIGINATED and perfected the dry or diaphragm type of draft gage and today Hays Draft Gages are standard equipment in thousands of the nation's boiler rooms.

HAYS DRAFT GAGES are offered in a wide variety of types from the V-type, illustrated above, to recording gage. Send for our catalog today. Write to 925 Eighth Avenue, Michigan City, Indiana.

The HAYS CORPORATION
MICHIGAN CITY INDIANA, U.S.A.

Strip-Chart Recording Demand Meter

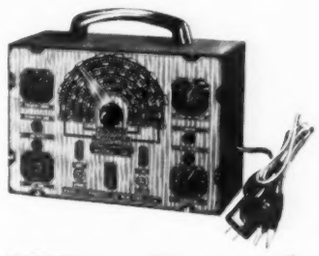
A new contact-operated, strip-chart recording demand meter combines a two-circuit totalizing relay and a recording demand meter. The new instrument may be employed for single circuit demand metering or for totalizing the demands of two circuits. In combination with totalizers or totalizing relays it may also be used to record the totalized demand of any number of circuits. Instead of the conventional plunger, coil, and ratchet arrangement the meter is actuated by Telechron motors controlled by three-wire contacts. It is suitable for a wide range of load demands and provides a continuous record of at least one month's operation on a chart 6" wide.—*General Electric Co., Schenectady, N. Y.*

Air-cooled Transformers

There is announced a complete new line of air-cooled transformers—1 va. to 10 kva.—for economical operation of industrial plant equipment. These units are said to be low in price but built to maker's high standards. Special requirements will have the immediate attention of maker's engineering staff.—*Ferranti Electric, Inc., 30 Rockefeller Plaza, New York City.*

Signal Generator

New "Model 702" signal generator provides fundamental, continuously-variable frequencies from 95 kc. to 25 Mc. with harmonics extending useful range to 100 Mc. All ranges are directly calibrated in frequency. Provision is made for direct tuning or through a 5-to-1 planetary drive. Chassis and cabinet provide triple shielding; coil assembly, attenuator and r-f. circuits are individually double-shielded. Thorough filtering in the power supply and an electrostatically shielded power transformer avoid feedback into the line. Sine-wave, 400-cycle modulation (30%) is provided by a built-in oscillator for use when desired. This modulation frequency is also available for external use and there is provision for applying external modulation to the signal generator output (desirable in oscillographic wave analysis). Attenuation obtained by means of the 5-step ladder attenuator is variable over the range of 1 microvolt to ½ volt with approximate calibration in microvolts. Instrument is a-c. operated and doubly protected by quick replacement fuses. Overall size is 8" × 11¾" × 5". All controls and terminals are clearly labeled.—*Radio City Products Co., 88 Park Place, New York City.*

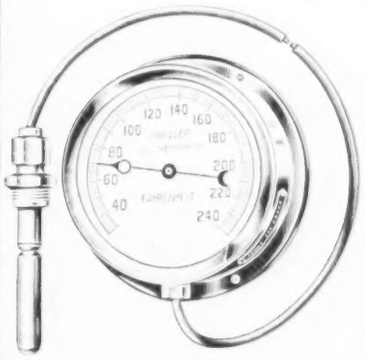


MOELLER PRECISION GRADE INSTRUMENTS

★

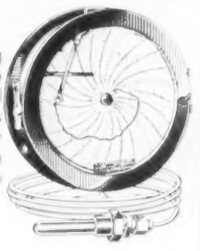
Our mercury thermometers are made with the Moeller Glass Red Reading Column which makes them easy to read under varying light conditions, at a considerable distance and over a wide range.

★



Moeller dial thermometers are made in various scale ranges up to 1000°F. or equivalent in both Metal and Phenolite cases.

Moeller recording thermometers are likewise furnished in various ranges up to 1000°F. or equivalent in both round and square cases.



Other products include

HYGROMETERS
RECORDING PSYCHROMETERS
BAROMETERS HYDROMETERS
MARINE INSTRUMENTS, ETC.

Write for catalog.

MOELLER INSTRUMENT COMPANY
132nd STREET and 89th AVENUE
RICHMOND HILL NEW YORK

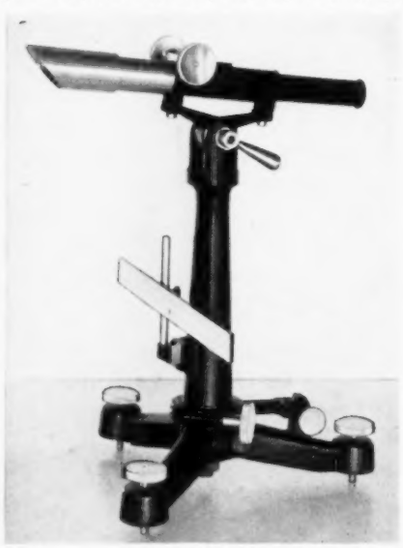
Pressure and Draft Controller

"Type P212A Electric Static Pressure Regulator" consists essentially of an equal-beam balance with two bell floats and with a contacting arrangement at one end of the

beam. As a pressure instrument it is of the bell float class, balanced double bell type, with single central-knife-edge balance beam and two independent balance weights. Fine adjustment of lever lengths of both weights is accomplished by screws and lock-nuts. Electrically, new controller is of the two-contact type with "high" and "low" contacts independently adjustable. *Pressure range:* Positive pressure 0 to ¾" water column (incl. differential) negative pressure 0 to 1" water column (incl. differential); these limits based on tank containing one gallon of "Finol." *Differential:* min. 0.02", max. 0.6" water column. *Electrical rating:* 1 amp. at 25 v., ½ amp. at 110 v., ¼ amp. at 220 v., a.c. Static Pressure Regulator is designed for use with a "floating" motorized damper or similar device, for fan systems, combustion control applications, etc.—*Minneapolis-Honeywell Regulator Co., 2950 Fourth Ave., South, Minneapolis, Minn.*

Reading Telescope

New "No. 220" mounted reading telescope has been designed to meet requirements of steadiness, easy and smooth adjustment, absence of parallax, wide range



of focus, and rack and pinion focusing. 1¼" aperture results in well-illuminated images. Telescope is constructed of heavy bronze castings well fitted for smooth operation and great steadiness. Focusing is by diagonal rack and pinion with a fixed ocular position. A reticle in the ocular provides fine, well visible reference lines. Instrument may be used over the range of 25" to infinity. When necessary to focus at close distances, ocular is partly drawn out of its tube to increase tube length beyond range of rack and pinion. Millimeter scale makes instrument suitable for galvanometer or optical-lever use. Column rotates on ball bearings that are preloaded to provide free action with complete absence of back-lash and minimum friction. A clamp permits hand adjustments in azimuth, and a fine thread tangent screw provides close settings. Magnification is about 15× for distant objects. Telescope proper can be furnished as a separate unit (unmounted).—*Mico Instrument Co., 10 Arrow St., Cambridge, Mass.*

NOW

Wheelco Series 3200

POTENTIOMETER CONTROLLER

Matching the unusual sensitivity of the Famous CAPACITROL control system with the well established accuracy of the potentiometric method of temperature measurement, Wheelco again leads in supreme performance by offering this unbelievable solution for control problems of extreme accuracy and sensitivity.

Write for Bulletin 3200

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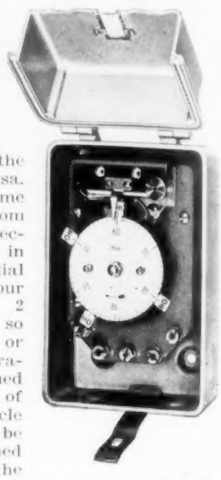
Cycle Controller

New "Type C.T. Cycle Timer" has been designed for use on a-c. circuits to (1) continuously close and open a single circuit at any pre-set operating interval, or (2) alternately close and open two circuits at any pre-set operating interval, one circuit opening instantaneously with the closing of the other and vice versa. It has eight time scales ranging from one rev. in 60 seconds to one rev. in 24 hours. Each dial is equipped with four operating arms, 2 "on" and 2 "off" so that either one or two cycles of operation can be obtained in one revolution of the dial. Either cycle of operation can be independently timed in respect to the other. Operating arms are adjusted by loosening a knurled hand screw and sliding operating arm to desired time setting. Timing motor will start on ±20% of rated voltage, will stay in synchronism "far beyond a satisfactory operating voltage for other equipment." Light-weight rotor and slow-speed gears are provided with adequate supply of sealed-in lubricant, require no special attention. Torque is several times greater than that required to operate dial and switch mechanism. Switch mechanism has snap action with positive lock in both operating positions. Its action imposes practically no load on the gear train. Silver butt-to-butt contacts are amply rated to carry a ½ h.p. motor load, a 1200-watt heater load or a 1000-watt lamp load. Die-cast housing, for surface mounting, is moisture- and dust-proof; is provided with a glass window, a hasp for padlocking and four knockouts for either ½" or ¾" conduit connection.—*R. W. Cramer Co., Inc., Centerbrook, Conn.*



Signal Generator

Precision signal generator Series E-200 features the exclusive Precision A.V.C. substitution method for simplified, accurate radio receiver alignment. The E-200 supplies

its own A.V.C. voltage. Six bands from 110 KC to 72 megacycles. Direct reading. Maximum 1% deviation on all bands under widely varying climatic conditions. 400 cycle sine-wave oscillator, incidentally controlled. Calibrated modulation control provides 0-100% modulation of RF signal, at will.—*Precision Apparatus Company, 647 Kent Ave., Brooklyn, N. Y.*

★

Moisture Teller

★

Rapid and accurate moisture test in percentage by drying. Drying temperature controlled by thermostat. Ideal for plant moisture control or laboratory moisture determinations.

Time required to dry most materials is one minute.

Suitable for granular—fibrous—crystalline materials is industries such as:

Sand—Textile—Tobacco
Ceramic—Rubber—Food
Wood—Mining—Leather

Write for Literature

Harry W. Dietert Co.
9330-C Roselawn Avenue
Detroit, Michigan

Molten Steel Carbon Determination Apparatus

For making rapid carbon determinations of the bath in open hearth furnaces, "Carbanalyzer" has been developed by the Research & Development Div., Gen. Metallurgical Dept., Jones & Laughlin Steel Corp., Pittsburgh, and made available to the entire steel industry. It is said to be substantially comparable in accuracy with chemical analysis and in speed with the traditional fracture test, to be designed for use under mill conditions and to give trouble-free service. Being portable and self-contained, it may be set up and used in any convenient location. Temperature changes or normal mill vibration do not affect accuracy of results, it is said. Carbanalyzer is calibrated by checking its readings against carbon determinations by chemical analysis and since resulting curve is reasonably smooth, a relatively small number of these comparisons are sufficient. Readings are taken in a few seconds. Complete operation, including preparation of sample, requires three to five minutes.—*Licensee: Fisher Scientific Co., 711 Forbes St., Pittsburgh, Pa.*

Motor-car Test Voltmeter

New "F-8 Voltmeter" was designed to meet requirements of an all-purpose handy instrument for checking batteries, wiring, voltage regulators, and voltage drop in all circuits of automotive vehicles. Instrument has a d'Arsonval moving coil precision movement in a Bakelite case. Etched metal dial has a 0-3 volt scale in tenths (used for checking voltage drop), and a 0-15 volt scale, in two-tenths, used for checking generator, voltage regulator, headlight circuits, etc. Range change is accomplished by pressing a push-button, without removing or replacing any connections to units being tested. Instrument is furnished complete with two prods, leads and clips. Both prods may be used at one time, or both clips, or a prod and clip. Operating instructions, easy to understand, include a number of helpful illustrations.—*Allen Electric & Equipment Co., Kalamazoo, Mich.*

MAKE YOUR PLANT
EXPLOSION PROOF
24 HOURS A DAY

FLAME-OTROL

is the only instant acting safety control designed to operate on gas, oil or powdered coal. FLAME-OTROL is the only instrument of its kind approved and listed by both Associated Factory Mutual and Underwriters Laboratory.

Write for Bulletin No. 1101

Wheelco Instruments Co.
1929-33 S. HALSTED STREET • • • CHICAGO, ILLINOIS

IMPROVED "SPOTLIGHTS"

Rubicon MULTIPLE REFLECTION galvanometers have recently been much improved through redesign of optical system. The definition of the line-image is now so sharp that readings can be estimated to .1 of a millimeter division.

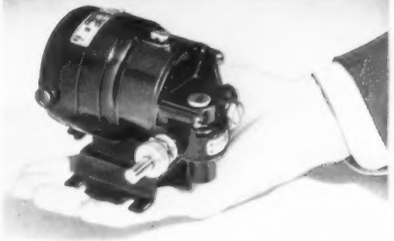
These sturdy self-contained galvanometers are available with sensitivities as high as 5×10^{-10} ampere and 1×10^{-6} volt per millimeter division.

ASK FOR BULLETIN 320

RUBICON COMPANY
Electrical Instrument Makers
29 North 6th St. Philadelphia, Pa.

Galvanometers, Electrometers, Potentiometers, Colorimeters, Wheatstone & Kelvin Bridges, Resistance Standards, Resistance Boxes, Coil Testers Clip-on Ammeters, etc.

Speed Reducer Motors for INSTRUMENTS



If you need a fractional horsepower speed reducer motor for your instruments, Bodine can meet your exact requirements. There are more than 1600 standard speed reducer motors in the Bodine line, from 1/2000 to 1/6 horsepower, with speeds from 1 to 300 rpm, and torques up to 300 in-lbs. The finest instruments are driven by Bodine motors.

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BODINE ELECTRIC CO.
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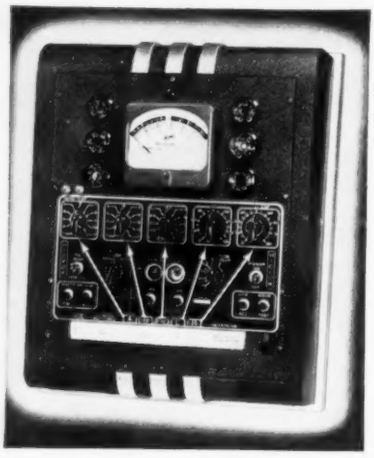
BODINE

Dynamic Mutual Conductance Tube Tester

New "No. 530" Tube Tester measures dynamic mutual conductance on three ranges of Micromhos (0-3000-6000-15000)—a basic patented circuit testing tubes to manufac-



turers' and engineering standards. Dual reading scale indicates "Good—Bad—Doubtful" as well as micromhos. Roll chart has been greatly enlarged. Note arrows pointing from chart on tester panel. Instrument tests all tubes: octal, loktal, ballast, up to 117-volt filament type tubes, "Magic Eye" tubes, new battery tubes, gas tubes such as OZ 4, OA 4, etc. and pilot lamps. Among exclusive features: Checks gassy tubes, detects both short and open elements—short tests made hot or cold—diode plates tested separately. Available in both counter type (illustrated) and portable type case.—*The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio.*

Pocket Multitester

New "Model 412" multitester unit of pocket size, yet capable of a wide variety of measurements, employs a 400-microamp. d'Arsonval movement with an Alnico mag-

net, housed in a 3" square Bakelite case mounted on metal panel of the unit, surrounded by labeled terminal jacks, selector switch and zero adjustment knob. Case measures 3¼" × 2⅝" × 6". Self-contained battery provides for all resistance measurement ranges up to 1 megohm. Thirteen ranges are provided as follows: D-c. volts 0-10/50/250/1000/5000 (all at 2500 ohms-per-volt sensitivity), d-c. microamps. 0-400, d-c. milliamps. 0-10/100/1000, d-c. amps. 0-10; resistance 0-500/100,000/1 megohm. Resistance measurements as low as 0.1 ohm and current measurements of only 8 microamps. are said to be easily read. Manufacturing tolerance is 2% maximum error for meter, shunts, multipliers, etc., insures overall accuracy beyond the requirements of most service and experimental applications. —*Radio City Products Corp., 88 Park Place, New York City.*

Vacuum . . . Thermocouples

A COMPLETE LINE

embodying many unique features

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- DEPENDABLE STABILITY
- MORE EFFICIENT
- HIGHER OVERLOAD
- FASTER RESPONSE
- SMALLER SIZE—½"x1"
- LOWER COST

These thermocouples will meet the most rigid specifications. Prompt delivery is assured. Write your requirements to:

AMERICAN Electrical Sales Co., Inc.
67 E. 8th St. New York, N. Y.

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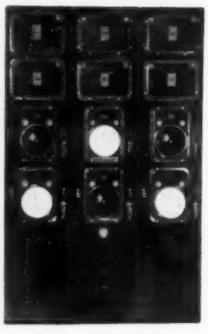

STEEL PANELS

FALSTROM Precisioned Steel Panels are specified by engineers for their Strength . . . Durability . . . Fine Appearance . . . for use in—

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OIL REFINERIES
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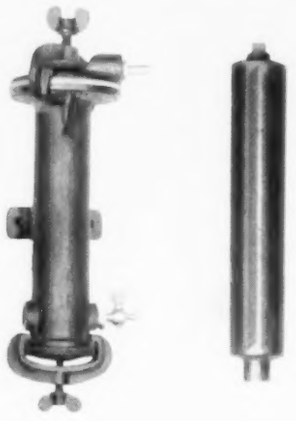
FALSTROM COMPANY of PASSAIC N. J.

Flue Gas Filtering System for CO_2 Instruments

Realizing that a CO_2 recorder installation is no better than its gas filtering system, company has devoted attention to development of a filter having following char-



acteristics: (1) High strength—to permit blowing out with high pressure air or steam and to provide greater ease in handling. (2) Large capacity—to provide longer operation with less attention; and (3) Low draft loss—to insure free gas flow even after the filter capacity is partially exhausted. As a result, primary gas filter, Part 26240, has replaced the porous tube filter. It comprises two concentrically arranged finely slotted steel tubes having the annular space filled with a sharp, closely-graded granular material which forms the filter bed. Blowing out is not required as often and when it is necessary, can be accomplished with any pressure air or steam which will not only remove soot from outer section of filter but also drive pipe line rust and corrosion through the filter. Maintenance is thus considerably reduced. Fitted with a ¾" pipe coupling and requiring no special fittings, it may be readily substituted for the old porous tube filter. An auxiliary filter, Part 26230, used in connection with the steel wool filter, as a further safeguard against finely divided soot entering the instrument, is a disk of woven glass cloth (Fiberglas), inserted in a rubber ring, placed between the body and a modified steel wool filter top outlet cover provided with a recessed dome and outlet nipple. Fiberglas acts purely as a mechanical strainer, removing whatever traces of soot and fly ashes might pass through Primary Gas Filter and in no way supplements or interferes with the chemical removal of corrosive gas by the steel wool.—*The Permutit Co., 330 W. 42nd St., New York City.*

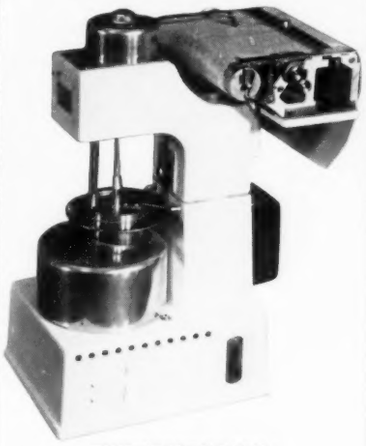
Non-breakable Transparent Front for Gages

Made of transparent plastic with tensile strength of about 5000 lbs./in.² and compression strength of about 15000 lbs./in.², "Transparent Gauge Cover" eliminates breakage of glass fronts by replacing them. It threads onto gage case, makes gage easier to read, makes case moisture- and dust-proof, is available for maker's 4½" and 6" phenol case "Duragauges."—

Ashcroft Am. Gauge Div., Manning, Maxwell & Moore, Bridgeport, Conn.

RECORDING VISCOSITY

With Automatic Constant Speed Temperature Increase



THE VISCOGRAPH

Recording Viscosimeter, with the following novel features:

1—Automatic constant speed temperature increase—from room temperature to 150° C.

2—Constant temperature, adjustable to any point within the above range.

The Viscosity is recorded continuously by means of a curve.

The VISCOGRAPH has been applied successfully in the testing of:

Oil	Glue	Artificial Silk
Printing Ink	Detrin	Starch
Latex		Flour, etc.

BRABENDER CORPORATION

ROCHELLE PARK, N. J.

Generator Voltage Regulator

New "Diactor" generator voltage regulator, "GDA" for use with a-c. and "GDD" for d-c. machines, is an improved "streamlined" design of the "Type GDA" (thor-

oughly described in March 1935 *Instruments*, page 84). It is announced in six ratings for generators rated 15,000 kw., 3600 r.p.m. and smaller machines at correspondingly lower speeds. The smallest is designed for generators up to 25 kw. New regulator is of the quick-action, wide-range rheostatic-type, with an improved torque element which eliminates all pivots and bearings. (A self-aligning spring suspension precludes all maintenance at this point.) Reduction of weight in torque assembly has cut down inertia, providing a smoother regulation curve. New design has also a totally enclosed case to prevent entrance of dust and dirt and to improve appearance of switchboard.—*General Electric Co., Schenectady, N. Y.*

A 24-HOUR RECORD—giving accurate and dependable measurements so vital to efficient and economical operation.

Hays Combustion Meters employ the Orsat principle for measurement of CO_2. Water operated — no moving parts—extreme accuracy coupled with dependable performance.

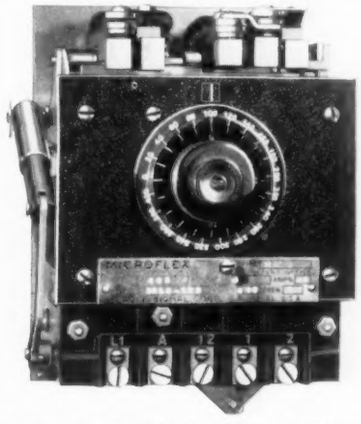
There is a Hays Combustion Meter to fit every requirement—remote or integral mounting, indicating or recording or both. Write to 925 Eighth Avenue, Michigan City, Indiana, for free catalog.

The HAYS CORPORATION

COMBUSTION INSTRUMENTS AND CONTROL — MICHIGAN CITY, INDIANA, U.S.A.

Instantaneous Reset Counter

This new Microflex counter is a relay for limiting the number of operations of a machine or part in a processing cycle; i.e., control circuits of automatic machine tools



and process controls in which a contact is to be closed for a predetermined number of operations. It is fully automatic, requiring only electrical impulses to accomplish the counting operation. Dial settings remain fixed through any number of cycles and need only be reset when operator desires to change the number of operations of the machine. Operation: one side of s-p, d-t, is normally closed, designated as contact No. 1; other side normally open, designated as contact No. 2. Operation is controlled entirely by two switches or contacts usually located on the device being controlled. Type of control switches used depends upon application. The first (controlling clutch coil) may be a momentary-contact push-button, limit switch, pressure switch, motor starter contact, etc. Likewise, impulse switch may be of construction suited to application. Standard models have a counting range of 0 to 400 in steps of 1. Number of operations for which counter is set is indicated on the compound dial located on front. This may be adjusted by loosening a thumb nut and rotating inner dial. Settings can be read at a glance. Inner dial is calibrated in steps of 1 from 0 to 20; outer dial ring is calibrated in units of 20 from 0 to 400. Each revolution of inner dial advances outer ring one unit division and the setting is the sum of the two readings.—*Eagle Signal Corp., Moline, Ill.*

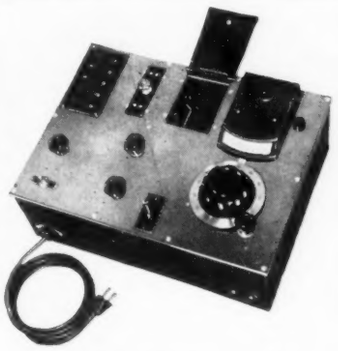


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PHOTO-ELECTRIC COLORIMETER

For 1" plane parallel sample holders with adapters for test tubes and micro-cells.

Line operated (no batteries), yet fully balanced for line voltage variations.

Zero-potential circuit for highest linearity of photocell response.

Models available with ample sensitivity for use with monochromatic filters.

Models available with 6" sample holder for accurate measurement of almost colorless liquids.

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Also

PHOTRIX Universal Photometer. Light meters of highest sensitivity.

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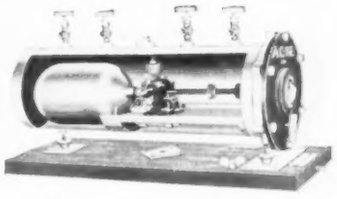


The AC-ME Gas Gravity Balance

A portable instrument for determining the specific gravity of any gas.

Results obtained are dependable and accurate as the instrument is designed on fundamental laws of Physics.

Spring Suspension is used for the Balance Beam which can be locked from the outside.

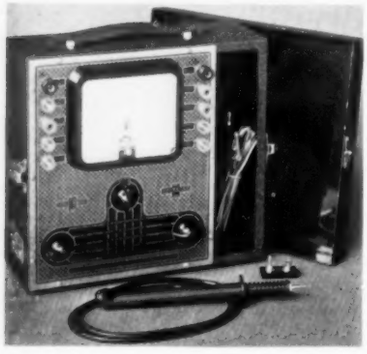
Write for description.

The Refinery Supply Co.

631 E. 4TH ST. TULSA, OKLA.

Multiple-purpose Tester

Protection against accidental contact with high voltages is provided in new "No. 220 Unimeter" by a special jumbo test prod with rugged finger guard and heavily insulated



lead which terminates in an insulated female connector. High-voltage terminals (3500, 7000 volts a-c., 5,000, 10,000 volts d-c.) fit only the connector on special test lead. A-c. ranges are characterized by temperature coefficient unusually low for rectifier instruments: change of 18° F. will affect readings only 1%. *Ranges*: D-c volts: 0-5-20-100-500-1000-5000-10,000, sensitivity 20,000 ohms/v. A-c volts: 0-3.5-7-35-140-700-3500-7000, sensitivity 7000 ohms/v. Reads to 0.25 volt. Output a-c.: Same as a-c. volts. Decibels: — 16 + 6, — 10 + 12, + 4 + 26, + 16 + 38, + 30 + 42, 6mw., 500-ohm level. D.c.: 0-50-500 microamps., 0-5-50-500 milliamps., 0-5-20 amps. Resistance: 0-3000-30,000 ohms, 0-3-30 megohms. Scale center, 27,270, 27,000 ohms, 0.27 megohms. Reads to 0.5 ohm. — *The Clough-Brengle Co., 5501 Broadway, Chicago, Ill.*

Compressed-gas Capacitor for High Voltages

This new standard of capacitance and power factor is of guarded terminal construction with no solid dielectric in the field of the measuring electrode. Its general features are: capacitance of measuring electrode to high-voltage electrode, 240 $\mu\mu$f.; spacing of electrodes, 1"; gas, nitrogen, CO_2, or one of the halogenated hydrocarbons at 150 to 175 lbs./in.^{2}; voltage rating, 100 kv. at 60 cycles with breakover considerably above this value; concentric cylinder design with the high-voltage electrode, the inner cylinder, supported upon heavy porcelain insulators. Guard electrodes, coaxial with the measuring electrode, are supported upon it by Micalex bushings which are not exposed to the high-voltage field. Assembly of measuring and guard electrodes is also supported upon the tank walls by other Micalex bushings which are completely shielded from the high-voltage field. Electrode surfaces are worked to an almost optical polish to remove those subvisible imperfections that might cause corona and initiate breakdown. Method of high-voltage cylinder support permits using the unit with high-voltage bushing up or base up if necessary to suspend the device from an insulator string. Low-voltage electrodes are insulated from tank to permit its use as a 4-terminal capacitor. Max. diam. 18"; tank height 50"; over-all 77".—*Mico Instrument Co., 10 Arrow St., Cambridge, Mass.*

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THE ONLY SINGLE BUTTON ELECTRICAL RETURN FLUXMETER
SIMPLEST AND MOST EFFICIENT
Bulletin 504
THREE DIFFERENT STYLES
Portable Standard with single electrical zero return.
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Two Button Pointer Shift in place of our patented standard zero return at a lesser cost.
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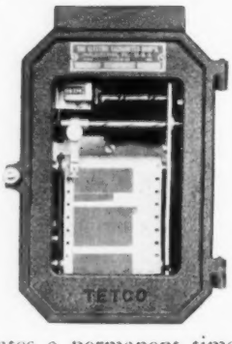
TETCO
Speed Recorder



Creates a permanent time record on a waxed chart. Accurately records rate of production, time and duration of stops, total quantity produced.
The Electric Tachometer Corp.
1358 Spring Garden St., Philadelphia, Pa.

REX RHEOSTAT CO.
37 WEST 20TH ST.,
NEW YORK, N.Y.
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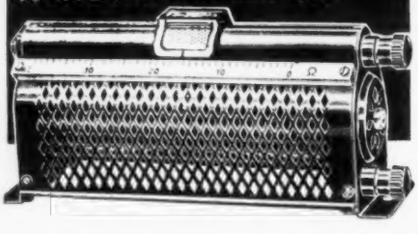
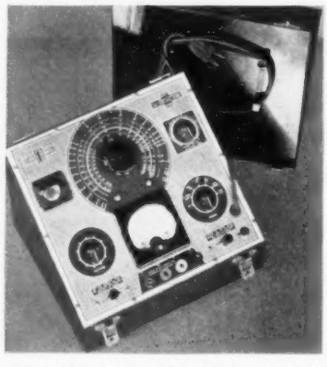


One-meter Cathetometer

Actual measuring range of new "No. 23[illegible] cathetometer is 102 cm. Millimeter scale is read by vernier to 0.05 mm. Telescope will focus on objects at a distance of 1 to [illegible] meters or more, may be rotated about its horizontal axis. Cast-iron column is thoroughly annealed between rough and finish machining and, after aging, scraped to an exact plane. Carriage is fitted by dovetail to it and lapped in after final scraping. Carriage is counter-balanced, has a self-contained fine adjustment. Column is carried on ball bearings that provide rigid mounting that is almost friction-free. These bearings are preloaded against each other to insure permanence of alignment. A fine-adjustment screw permits exact azimuth settings. General arrangement of telescope and slide is convenient in that the reference scale is always in sight from the reading position. Magnification can be varied; telescope uses standard microscope oculars. Telescope aperture is 1¼". Cathetometer can be fitted with two telescopes when desired. Such an arrangement permits checking over the full 102-cm. range, but does not permit either telescope to travel 102 cm.—*Mico Instrument Co., 10 Arrow St., Cambridge, Mass.*

A-c. Bridge

In new "No. 230" a-c. bridge, up to 550 volts d.c. can be applied to condensers during capacity measurement, so as to insure correct readings of capacity and power factor under conditions of actual use. Electrolytic leakage is checked with speed, accuracy and meter-safety by an exclusive inverse voltage drop method, and read directly on a new "Leakage-per-mf." scale, with rejection calibrated to U. S. Navy specifications. Leakage-resistance is by volt-ammeter method; range is up to 2500 megohms, read directly. Both electrolytic leakage and leakage-resistance tests can be made (through toggle switches) with the same control settings for measuring capacity. *Ranges:* Capacity: 2 mmf. to 200 mf. in three ranges; also shows opens and shorts. Resistance: 2-5000 ohms, 5000 ohms-20 megohms. Inductance: with external standards, as desired. Paper power factor: 0-0.5%, on second capacity range. Electrolytic power factor: 0-50%, on third capacity range. Transformer turns ratios: 0.01-100. Leakage-and-insulation resistance: 0-2500 megohms. Electrolytic leakage test: direct reading "Leakage-per-mf" scale as above. — *The Clough-Brengle Co., 5501 Broadway, Chicago, Ill.*



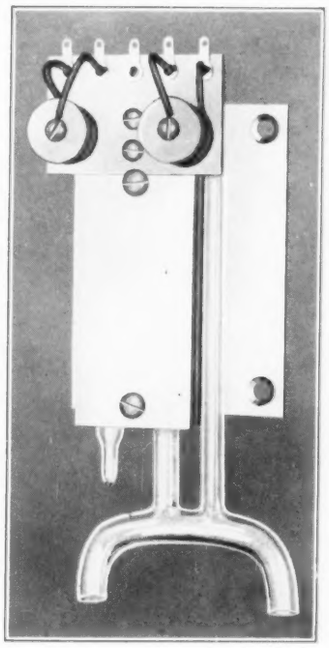
Portable Varmeter for Measuring Reactive Kva.

Without extensive wiring, expensive equipment, or cutting into the line, new "Type A-51" portable varmeter permits quick determination of current up to 300 amps, of

line volts, and of reactive kva. on power lines. Simple to operate and weighing 12 lbs., a lineman can clamp it on the line, connect the voltage dividers, and obtain readings of volts, amperes and vars by the operation of a selector switch. Scale illumination assures accurate readings in poor light or at night. New instrument employs an electrostatic wattmeter element and measures vars (reactive volt-amperes) on a single-phase basis by indicating the product of amperes and volts, and the sine of the angle between these values. The jaws of a split-core transformer on top of the varmeter may be latched open (as illustrated), the instrument hung on the line, and the latch tripped with an insulated stick. This transformer supplies the element with a voltage proportional to the line current. Voltage dividers (three of which are illustrated), attached to the line by clamps, supply the definite fraction of line voltage. These dividers, two connected in series for single-phase, and three connected to form a Y box for 3-wire 3-phase, consists of plastic tubes containing resistors, a small capacitor, and a neon lamp which glows when the dividers are energized. Connections are made with these dividers by flexible leads with spring connectors. After varmeter and dividers are thus connected to the line, a selector switch may be set at end of tube projecting from these instruments. After range selector switch is set, an adjusting knob on end of tube is adjusted until the light beam index shifts from one point to another. The scale is then read and the actual vars, volts, or amperes determined by reference to curves supplied with each set of voltage dividers. —*General Electric Co., Schenectady, N. Y.*

Mechanical-time Starter

A new d-c. definite-mechanical-time starter for general-purpose constant-speed motors consists of a solenoid-operated multi-finger contactor with an overload relay. It is unique in that it employs a new time-delay escarement mechanism. In constant engagement with the operating shaft, this mechanism restrains the shaft in the starting motor, but permits quick opening through the action of a positive over-running clutch. The rating is up to 5 HP, 115 volts and 10 HP, 230 volts.—*General Electric Co., Schenectady, N. Y.*



ANALYZE CORROSIVE GASES

● The Engelhard All Quartz Thermal Conductivity Gas Analysis Cell is the answer to corrosion problems. The gas does not come in contact with any metal at any point in its passage through the unit. Positive calibration and continuous accuracy is assured.

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45 YEARS OF TEMPERATURE AND ★ HUMIDITY CONTROL ★

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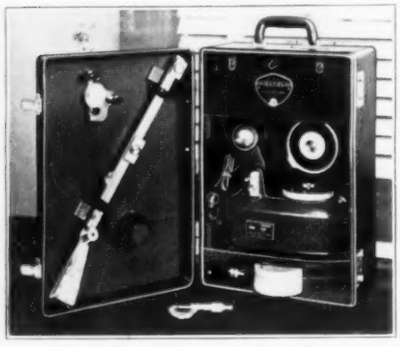
WITH PRECISION



Type J Taber Abraser Testing Outfit

ABRASERS are calibrated for standard wear measurements on paint, lacquer, molded or laminated plastics, electroplate, porcelain enamel finishes.

Other Models available for Woven and Knitted Fabrics of wool, cotton, rayon, silk, etc.

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TEMPERATURE CONTROL
MODEL Z, NON-INDICATING
Three Ranges: 50 to 350, 100 to 650 and 100 to 1,000 Deg. Fahr. Three Types of Micro Switches.

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RHEOSTATS
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National Electric Controller Co.
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SMALL DRILLS
from .0016 up to .1969 inch diameter, all sorts of small turned parts.
Small wood screws in brass, steel, etc., turned from the bar.

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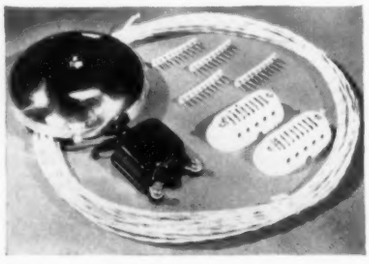
Bellows Type Flow-rate or Liquid-level Indicator

New "MJL No. 98 Rate of Flow Indicator" is essentially a differential pressure gage of the elastic-member class. When used as a flow indicator, it is connected to a primary

device such as an orifice, Venturi tube, or Pitot tube, inserted in the pipe line. The differential pressure actuates a calibrated bellows unit which drives the pointer. Instrument scale may be furnished to read directly in any units of flow desired, by using a square-root scale of suitable range. Use of a bellows unit eliminates possibility of mercury contaminating the measured fluid, or of injury to copper or brass fittings with which mercury amalgamates. Since mechanism has relatively small inertia and displacement, it is said that practically no accumulated error will result in readings, although leads to instrument are throttled in order to reduce effect of surges or pulsations. Indicator does not have to be accurately leveled, may be transported. It may be calibrated for any differential pressure range between 0-30" and 0-225" water column. To change range in the field, it is only necessary to insert a new calibrated bellows unit: there are no linkages to adjust. Either high or low alarm contacts, or both, may be supplied to operate a signaling device when the flow or liquid level reaches any predetermined point.—*Morey & Jones, Ltd., Room 215, 922 So. Hemlock St., Los Angeles, Calif.*

Fire-detection System

Sensitive element of "Fyre-Scout" fire-detection system is a thermostatic switch enclosed in an enameled housing, which closes the circuit and keeps it closed when a dangerous temperature is reached in its vicinity. All detector heads are wired in parallel and connected between a large fire gong and a 6-volt dry battery or a bell-ringing transformer. Basic kit comprises gong, two



detector heads, and 75 ft. of heavy-duty twisted-pair wire. Additional heads are available separately. Installation is said to be as simple as wiring a door bell.—*Technical Appliance Corp., 17 E. 16th St., New York City.*

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done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 30 years.

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CHRISTMAS SEALS

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AN "IRRESISTIBLE" INDUCEMENT

YOUR work is to solve problems. This is obvious if you head a plant or laboratory or department. It is true if you work in the field, out on your own. It is equally true if the payroll only lists you as a "student engineer" or "apprentice." Your own problems, or those of your employer, can be solved easily if you have the answers. The answers can generally be obtained by measurements. The ideal solution generally includes some form of control. Herein lies the reason why The Magazine of Measurement and Control is read by an ever-increasing number of technicians, engineers, executives, research men, production managers and many others. Throughout 1940, *Instruments* will bring you "the answers". The January issue alone will be of extreme value, because it will be a Special Issue, bound in two parts:

Part One—Featuring the twelve prize-winning essays of the Second Annual Instrumentation Contest. The themes of this Contest are "How Instruments Save Money" and "How Instrumentation Makes Jobs." These twelve prize-winning articles (and other meritorious essays awarded Honorable Mentions) will make Part One of the January issue a veritable "mine of information."

Part Two—*The 1940 Instruments Index*—Including a classified directory of ALL classes and types of instruments, meters, testing machines, control systems, etc., with names of ALL makers of ALL types. Also a directory of all the manufacturers, with (new this year!) descriptive data. This annual book has already won recognition. It will be even bigger and better!

The price of the January 1940 issue is two dollars. Some firms bought last January's two-part issue for this price (while there were copies left). But it is simpler and much wiser to subscribe now for all twelve issues to be brought in 1940: not only the big two-part January issue but other special issues to appear in 1940; and the smaller—but always valuable—"regular" issues.

Best and wisest procedure is to take advantage of the Group Subscription Plan. The idea is simple: office expenses being reduced when one reader sends one list of subscribers (new or renewal) with advance payment, the savings are passed on to you:

1 one-year subscription.....$2.00	4 one-year subscriptions.....$4.20
2 one-year subscriptions.....$2.40	5 one-year subscriptions.....$5.00
3 one-year subscriptions.....$3.30	Each additional subscription, add $1.00

Note how the total goes down. For example the instrument chief of a chemical company in West Virginia sent us a group of 46, the $47 total cost representing $1.022 per subscription or renewal.

To group organizers, special rewards. (See Page A6.)

This time (and this time only) a special inducement is announced—a gift of two useful texts—not only to group organizers but to every individual subscriber on every list received before December fifteenth. Here are these two texts:

Fluid Flow Measurement by Head Type Metering Elements
By
F. C. Stewart and J. S. Doolittle

Reprint of the book-length article in July 1939 *Instruments*. If printed as a book it would have 100 pages and sell for $1.50.

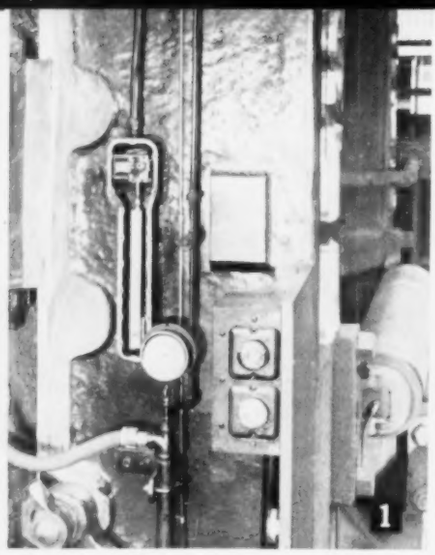
Measurement & Analysis of Noise and Vibration
By
Daniel Silverman

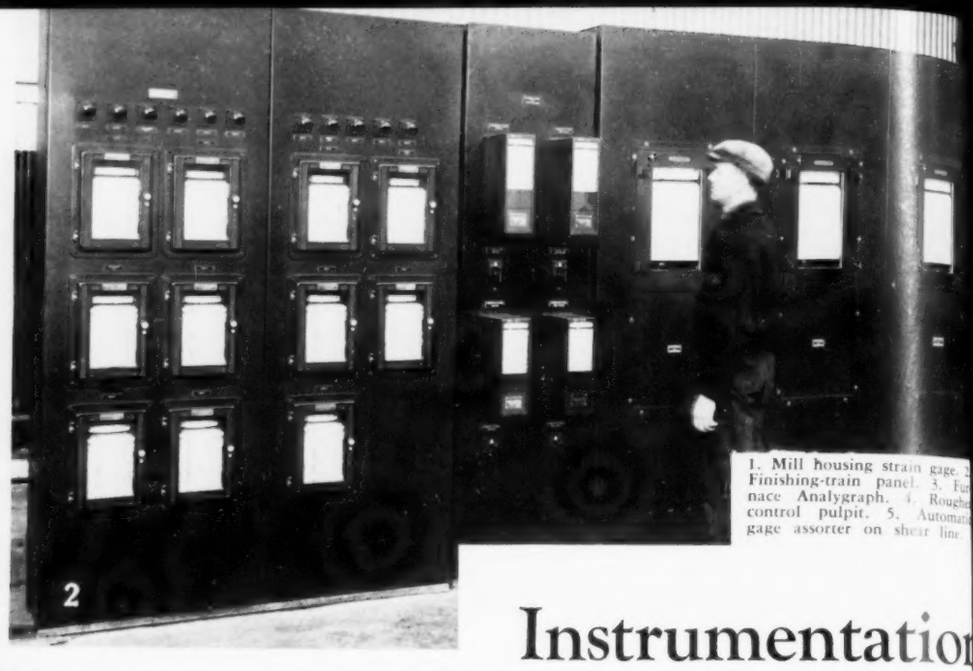
Reprint of the book-length article in August 1939 *Instruments*. If printed as a book it would have 120 pages and sell for $2.00.

We repeat: These two brochures (which would sell for $1.50 or $2 each if printed as books) will be sent to *every* subscriber on the lists received with advance payments at Group Rates, before December 15, 1939. If ever there was an "irresistible" inducement this is it! If you delay, you may not have a January 1940 Special Issue of your own and you will miss out on the two brochures. So don't delay! Join a Group, form a Group of your own—or just send your own subscription or renewal.

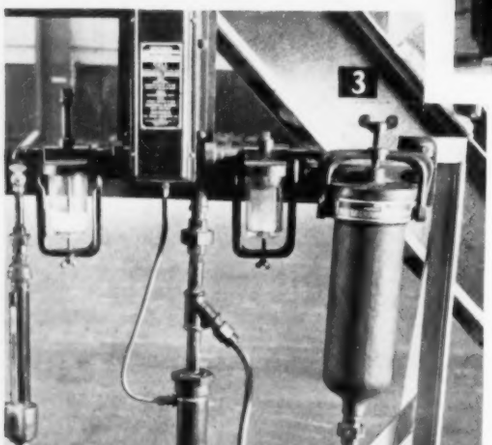
Instruments Publishing Co., 1117 Wolfendale St., Pittsburgh. Herewith is my list of ..... names and $..... payment in full as per Group Plan.

Individual's name | His address for mailing *Instruments* | Company | Position





1. Mill housing strain gage. 2. Finishing-train panel. 3. Furnace Analygraph. 4. Roughing control pulpit. 5. Automatic gage assorter on shear line



Instrumentation

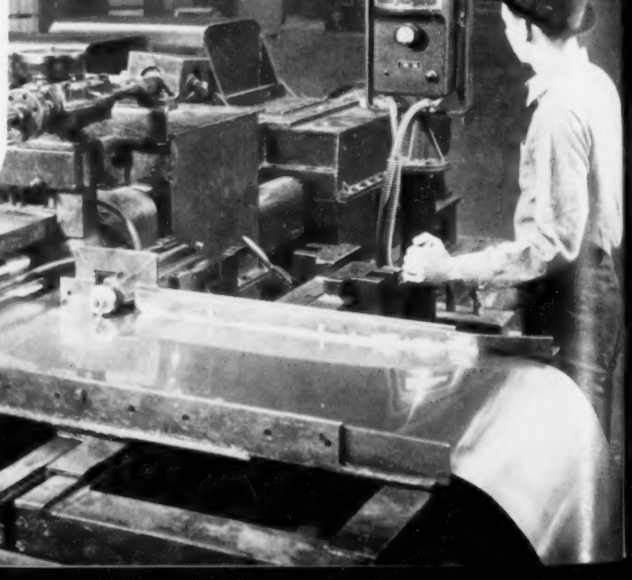
(Condensed from text released

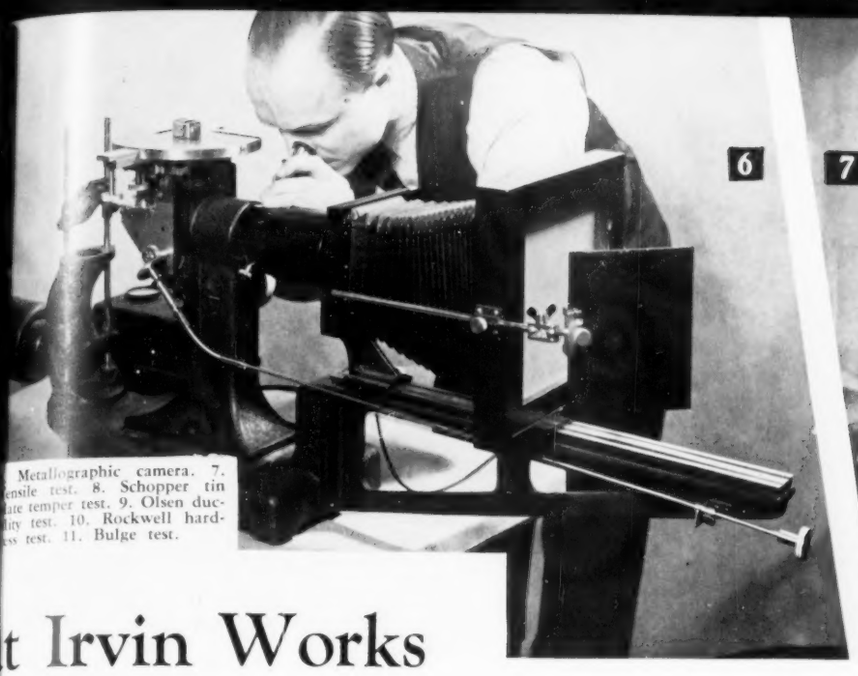
STANDARDS of quality set by the Carnegie-Illinois Steel Corporation for the products being rolled at its new Irvin Works are extremely severe. Their maintenance requires a high degree of instrumentation—both in the operating department (Front-cover photo and Figs. 1-5) and in the metallurgical department (Figs. 6-11).

No steel is produced at Irvin, most of the slabs being shipped in from the corporation's nearby Edgar Thomson plant. All slabs are identifiable as to analysis, heat and ingot position; piling is such as to permit the slab heating furnaces to be charged in proper sequence. These furnaces are triple-fired, zone-controlled, continuous units. Automatic instrument control of zone firing, combustion, atmospheres and temperatures permits utilizing maximum flame temperature in the primary heating zone and minimizes scale loss at either high- or low-capacity operation. The secondary heating zone is usually held at constant temperature and firing rate. Gas and air flows are automatically adjusted to give a slightly reducing atmosphere. To assure close coördination between the heating and rolling operations, the soaking zone temperature is ordinarily held within 10°F.

At the spreading mill, a pyrometer shows the operator the temperature of the slabs he receives, this temperature also being recorded at the furnace for the heater's information. Provision is made for holding the slab before it enters the squeezer to assure close control of that operation.

Rolling mill operating pulpits are provided with (*a*) equipment to control the rolling operations and (*b*) special equipment to enable the operating and metallurgical departments to determine the effects of speeds, temperatures, pressures, and other factors. Most primary elements are connected to one or more indicating instruments and to remotely-located recording instruments. For example, each roughing mill stand is equipped with a built-in strain gage head connected to a large pressure-indicating dial at the stand itself and also to a pressure recorder on the instrument board. An indicating pyrometer, read-





Metallographic camera. 7. Tensile test. 8. Schopper tin plate temper test. 9. Olsen ductility test. 10. Rockwell hardness test. 11. Bulge test.

t Irvin Works

negie-Illinois Steel Corp.)

ing at the floor station and in the pulpit, is installed immediately ahead of the finishing train. The steel not being allowed to enter the 80″ finishing train until it cools to the proper temperature, the roughing mill operator adjusts the speed of the tables accordingly. He is in constant communication by telephone with the roughing train and furnace operators to correlate temperatures, slab timing and speeds.

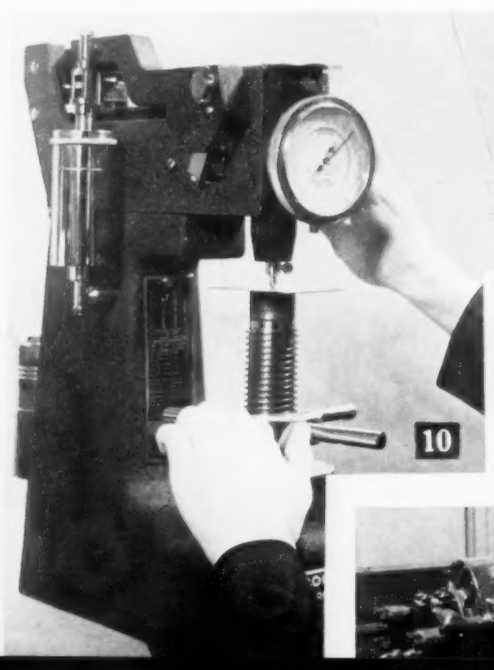
In the finishing mill pulpit, modern instrumentation on the operators' boards provides for close coördination of mill speeds and settings, table speeds, tension and other factors. As the temper of the coil is influenced by temperature, the metallurgical department specifies the finishing and coiling temperatures, and the operating department works out the details, starting with the temperature of the slab as it leaves the furnaces and adjusting sprays, mill speeds, etc., as required. A pyrometer is installed between the last two stands of the finishing train and the temperature of the strip as it leaves the train is held within 10°F. A second pyrometer is installed just ahead of the coilers, and the actual coiling temperature is held within 25°F. The coiling temperature varies between 1000°F. and 1350°F. according to the type of steel being rolled and the temper required.

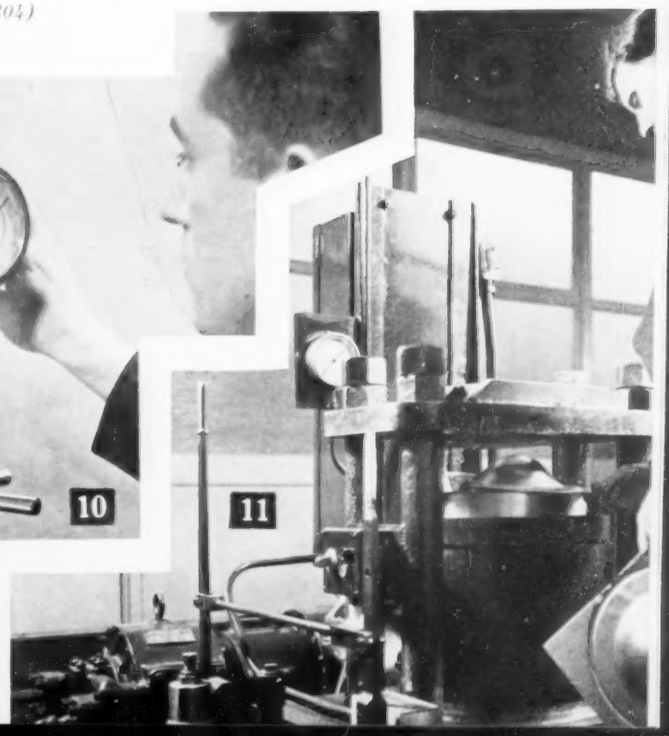
Strip temperature may be controlled after it leaves the mill by controlling three batteries of nozzles, approx. 72″ apart, without interfering with operating speeds. Strip speed varies between 1000 and 2000 feet per minute.

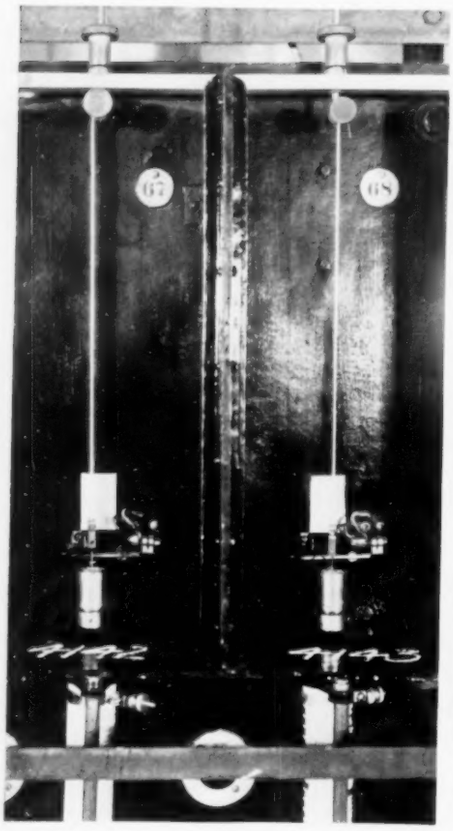
The metallurgical department constantly checks the product from the hot mill, samples being taken as soon as the material is cold. Routine tests include Rockwell hardness, tensile strength, ductility and microscopic examination of the structure, depending upon the use to be made of the finished product.

The maximum temperature at which coils are to be pickled is likewise specified, there usually being an interval of 24 to 48 hours from the time coils come from the 80″ hot mill until they enter the continuous pickling lines. Pickling

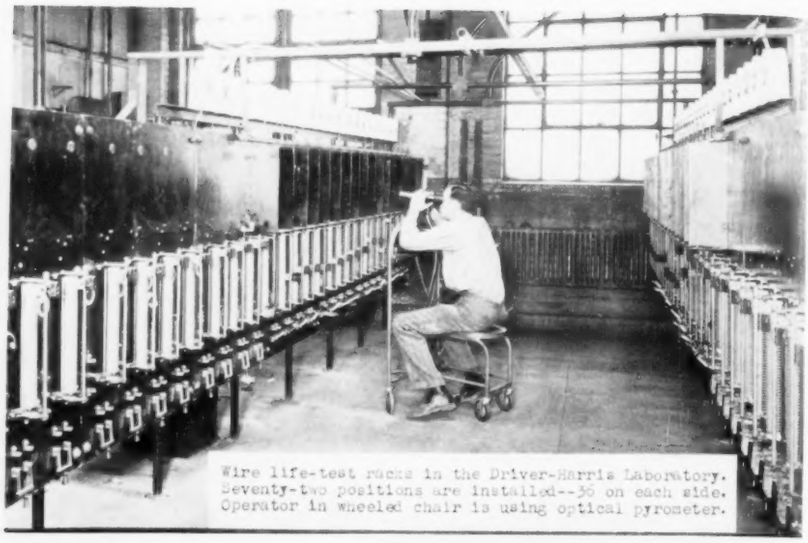
(Continued on page 304)



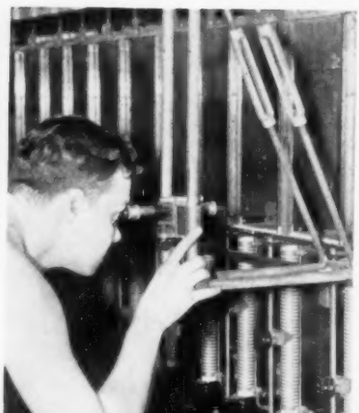




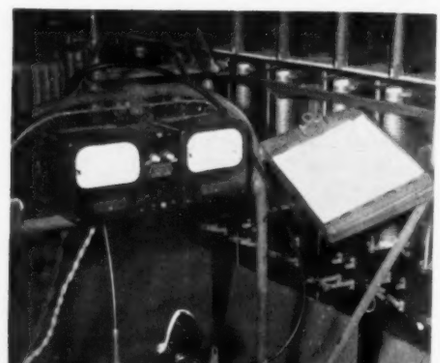
Close-up of room-temperature life-test positions. Screw clamp at top, 10-g. weight at lower end. Bottom contact established by mercury pool. Mercury switch on trigger bar is actuated when wire specimen breaks, and starts electric timer to indicate elapsed time between wire failure and reading. Scale back of weight is for measuring stretch.



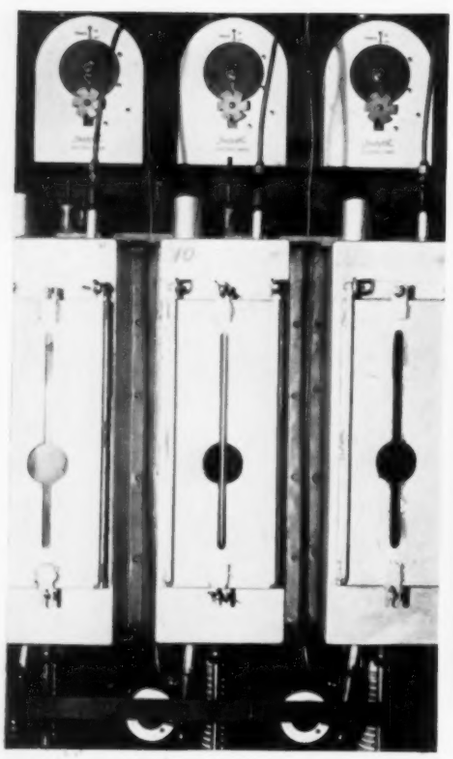
Wire life-test racks in the Driver-Harris Laboratory. Seventy-two positions are installed--36 on each side. Operator in wheeled chair is using optical pyrometer.



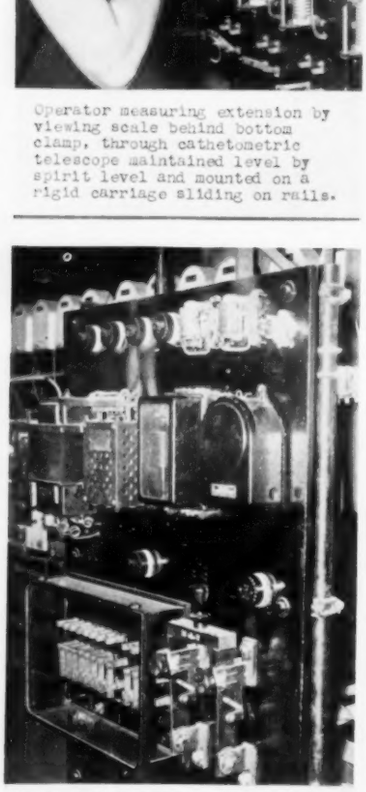
Operator measuring extension by viewing scale behind bottom clamp, through cathetometric telescope maintained level by spirit level and mounted on a rigid carriage sliding on rails.



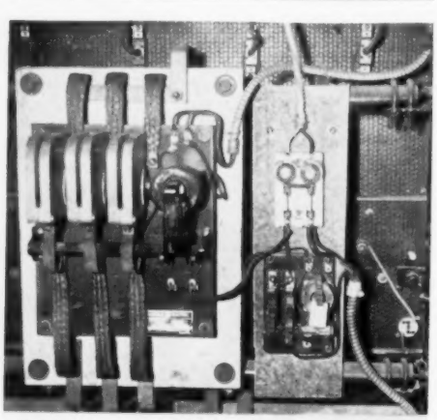
Wheeled chair for taking temperature and electrical readings. Top, Weston ammeter and voltmeter; below, L&N optical pyrometer used with a Hickok 0-550 milliammeter. Flashlight is used for observing conditions in compartments.



Enclosed life-test positions, permitting use of different gaseous atmospheres.



Rear of life-test racks, showing G-E time switch equipment for cycling the samples. One bank of 36 positions is on for two minutes then off while the other is on.



G-E relay and magnetically-controlled main switch for switching the power from one bank to the other, at two-minute intervals.

Instrumentation Removes Guesswork from Life Tests on Electric Heating-element Alloys

By F. E. BASH

Manager, Technical Department, Driver-Harris Co., Harrison, N. J.

UNCERTAINTY as to the life of electric heating-element alloys has been minimized by thorough instrumentation of the life-test equipment; and by thorough methods in checking and rechecking the output of alloy makers as well as their experimental melts.

The life-test equipment used in the Driver-Harris plant for controlling production quality and checking up in the development of new electric heating alloys, with particular reference to materials for high-temperature applications, is based on the A.S.T.M. standard procedure with certain refinements, additions and—we believe—improvements of our own.

In a relatively draft-free room we have two banks of 36 life-test panels or "positions" facing each other. Separators of asbestos board (not of metal) enclose the wire under test on three sides and at bottom, with a glass slide in front. Optical pyrometer readings are taken through the glass, with a correction of 10°F. The glass is wiped clean daily.

Temperature variations along the length of a vertical sample having been found less than in a horizontal wire, a length of each sample wire is mounted vertically between a fixed clamp at top and a 10-g. weight at lower end. A mercury pool establishes contact with bottom end of otherwise freely suspended wire.

The service life of a heating-element alloy means, first of all, the total number of hours the sample wire or ribbon will operate at temperature until it burns out. However, the second part of our life test has to do with resistance increase (and consequent temperature drop at fixed voltage). In our life tests we consider an alloy no longer useful when its resistance increase exceeds 10% of initial value. We determine the time to 10% resistance increase, and the time to burnout.

In actual service the life of a heating element alloy depends not only upon the length of time at temperature but upon the number of times it is cooled. The life of alloy heated continuously may be twenty or thirty times that of one tested under standard A.S.T.M. conditions. To obtain in hours what would occur in weeks or even months of normal service, we have (1) rapid heating and cooling cycles, and (2) operation of the sample at higher temperatures.

In our life-test panels wire samples are subjected to continuous cycling of 2 minutes on and 2 minutes off. This is the most severe condition that can be imposed on wire of the size used (usually 0.025"), because wire of this size attains the full operating temperature during the "on" period, and has time to cool to the ambient temperature during the "off" period.

The voltage regulator was built to order by the American Transformer Co. An Esterline-Angus recording voltmeter provides permanent records. Automatic cycling is accomplished by General Electric equipment.

The resistance and temperature of every sample are measured at regular intervals, with the convenient aid of the instrumentized wheeled chair shown on the facing page. The electrical instruments connect by plug and jack to any test wire. Individual slide-type rheostats permit each wire to operate at any desired temperature.

To determine the exact moment of burnout an interval timer for each test position indicates elapsed time between burnout and checkup. These Hotpoint self-starting electric timers, originally intended for electric range service, have 12-hour dials, so we have added a notched disk tripped by the timer each time around, to indicate multiples of 12 hours.

Two rails along the front of the test panels support a wheeled rack upon which rests a telescope with cross-hair and spirit level, used to observe expansion or "creep" of wire samples. A good alloy is characterized by minimal creep; and it attains the 10% resistance increase at about the same time as its burnout, while a poor alloy may show a long life to burnout if a high resistance develops quickly.

Since alloy users buy definite temperature and service-life characteristics, our life tests are of paramount importance in production control. Every melt poured in our foundry is first tested in the form of a wire sample before release for shipment. Here is the procedure:

A heat is cast. One ingot is rolled to rod, and a portion drawn to test size or 0.025" (0.64 mm.) dia. A life test is made immediately on two wire samples from each heat. Ingots from that given heat are held until life test is completed. No material is shipped unless it has a life in excess of a minimum value. The value set has been steadily increased ever since the inception of production control testing. Minimum limits allowed for approval are several times greater than when this test was inaugurated. Material falling below the minimum life requirement is scrapped. Weekly tests are run on a standard wire of comparison, and all tests on new wire are reported in terms of this standard. In control testing of production it is, of course, essential that the preparation of the sample for life test be completed as quickly as possible as otherwise a large inventory of unapproved ingots will accumulate.

For the 80-20 nickel-chromium alloys (such as Nichrome V) the test temperature was originally set by the A.S.T.M. at 1950°F. (1065°C.) and the average wire at that time burned out in about 100 hours. As improvements were made in the quality of nickel-chromium alloys, they were found to last much longer before burning out, with resultant delay in reporting and a growing accumulation of untested materials. It was then decided, on production testing, to increase the temperature sufficiently to cause the wire to burn out within one week. With still greater improvement in alloys, it was again necessary to increase the test temperature. At present, our production control routine calls for 2150°F. (1175°C.). This is an increase of 200°F. (111.1°C.) over the original test temperature. Wire made today lasts longer at this temperature than former wire did at 1950°F. (1065°C.).

We have reduced some of our life test findings to curves for the benefit of designers of electric heating equipment. These curves establish certain relationships between samples of the same wire operated at different temperatures with regard to life test and minimum hours of life at operating temperatures, as well as comparisons of different alloys with regard to total hours of life (standard intermittent heating) at operating temperatures up to 2300°F. More curves are being developed. Such data will further reduce the last remaining guesswork in the electric heating art.

Pressure-Spring

Characteristics of the Various Types

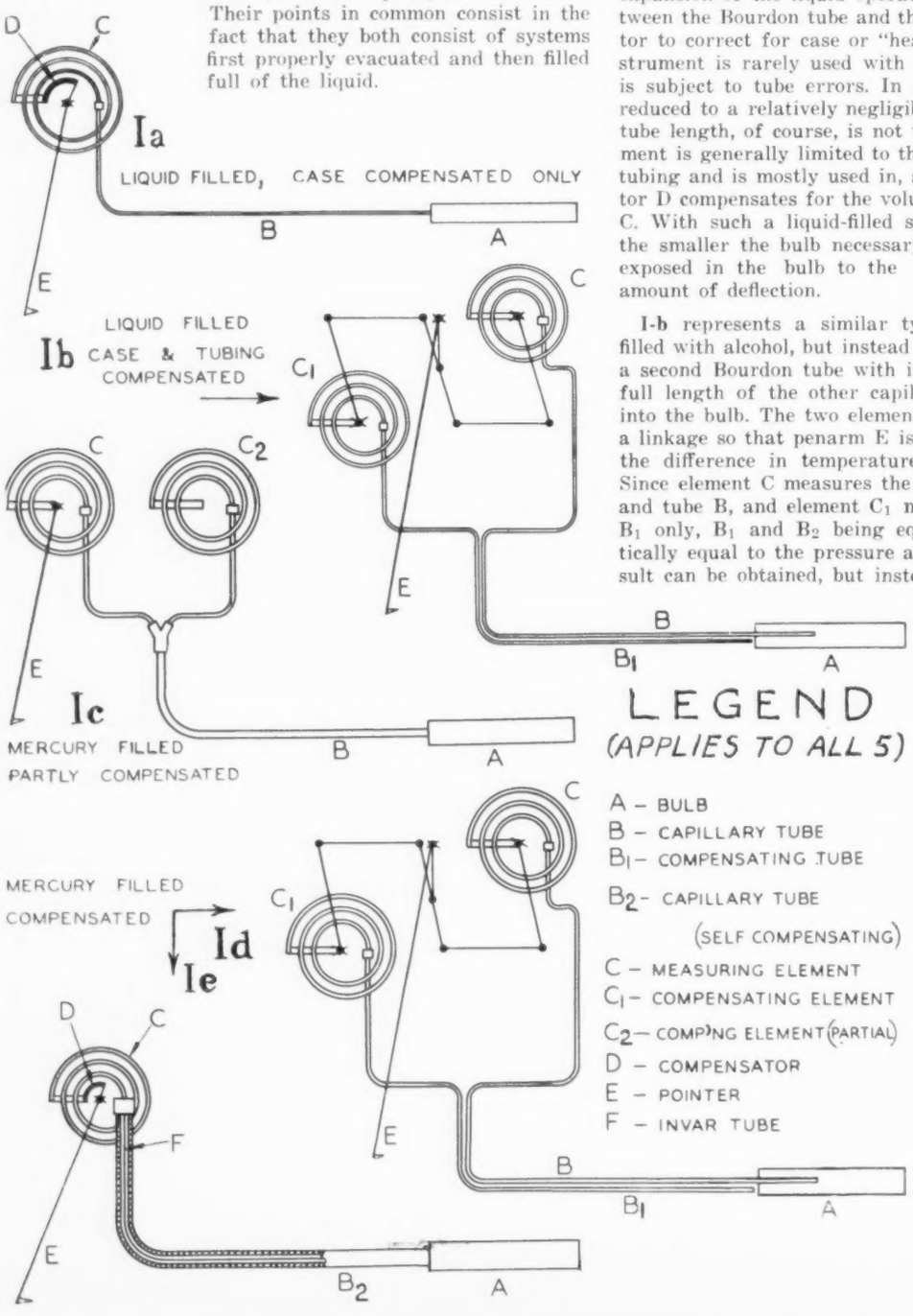
Condensed from paper presented at 1937 Annual Meeting of A.S.M.E.

IN industrial practice, almost all pressure-spring thermometers use some form of a Bourdon tube: circular, spiral, helical or involute. (Diaphragm types such as bellows or capsular springs being seldom used for strictly measurement functions, no special mention will be made of them herein.) It is not our object to promote or advance one type of system over another, but rather to attempt to generalize on all that are at present available commercially in this country.

Because the filling medium is the means by which the general classification of thermometers is most readily broken down and because the characteristics of instruments are more dependent on this than any other one factor, we shall consider each of the classes separately.

I—LIQUID FILLED

It is impossible to properly consider liquid-filled without first separating the two principal types, namely, mercury-filled and other liquids, such as alcohol. Their points in common consist in the fact that they both consist of systems first properly evacuated and then filled full of the liquid.



In order that these systems may be more easily followed, each type of system discussed is illustrated by a purely diagrammatical sketch. In actual manufacture, many of them employ somewhat more elaborate linkages than that shown, but the principles of operation are the same.

I-a shows the simple liquid or alcohol filled system. Such a system may be termed a case-compensated liquid-filled thermometer. It consists of bulb A, capillary tubing B, helical element C, case compensator D and pointer E. The expansion of the liquid operates the Bourdon tube, but between the Bourdon tube and the pen is inserted a compensator to correct for case or "head" temperature. Such an instrument is rarely used with long connecting tubing, as it is subject to tube errors. In actual practice, these can be reduced to a relatively negligible amount, provided that the tube length, of course, is not too long. This type of instrument is generally limited to the relatively shorter length of tubing and is mostly used in, say, 10 ft. or less. Compensator D compensates for the volume of liquid in Bourdon tube C. With such a liquid-filled system, the higher the range, the smaller the bulb necessary, since the amount of liquid exposed in the bulb to the temperature determines the amount of deflection.

I-b represents a similar type of instrument, similarly filled with alcohol, but instead of compensator D, it employs a second Bourdon tube with its capillary tube running the full length of the other capillary tube, but not connected into the bulb. The two elements C and C_1 are connected to a linkage so that penarm E is given a motion dependent on the difference in temperature between the two elements. Since element C measures the combined pressure of bulb A and tube B, and element C_1 measures the pressure of tube B_1 only, B_1 and B_2 being equal, the differential is practically equal to the pressure as exerted at A. A similar result can be obtained, but instead of mounting the two elements separately and connecting the resultant motion through a linkage, mount one element on the other so that the compensation differential is applied. Since the two coils C and C_1 are equivalent in volume and they balance out that pressure effect due to temperature inside the coil itself, no further case compensation is needed. Such an instrument has a much wider field of use than I-a and can be furnished with relatively long lengths of tubing with most satisfactory results.

(I-a may also represent the ordinary mercury-filled thermometer. Mercury having a high coefficient of expansion, naturally produces relatively high pressures. Working pressures of this type of instrument run as high as 2500 lbs./in.^{2} at the top. This high pressure nat-

Thermometers

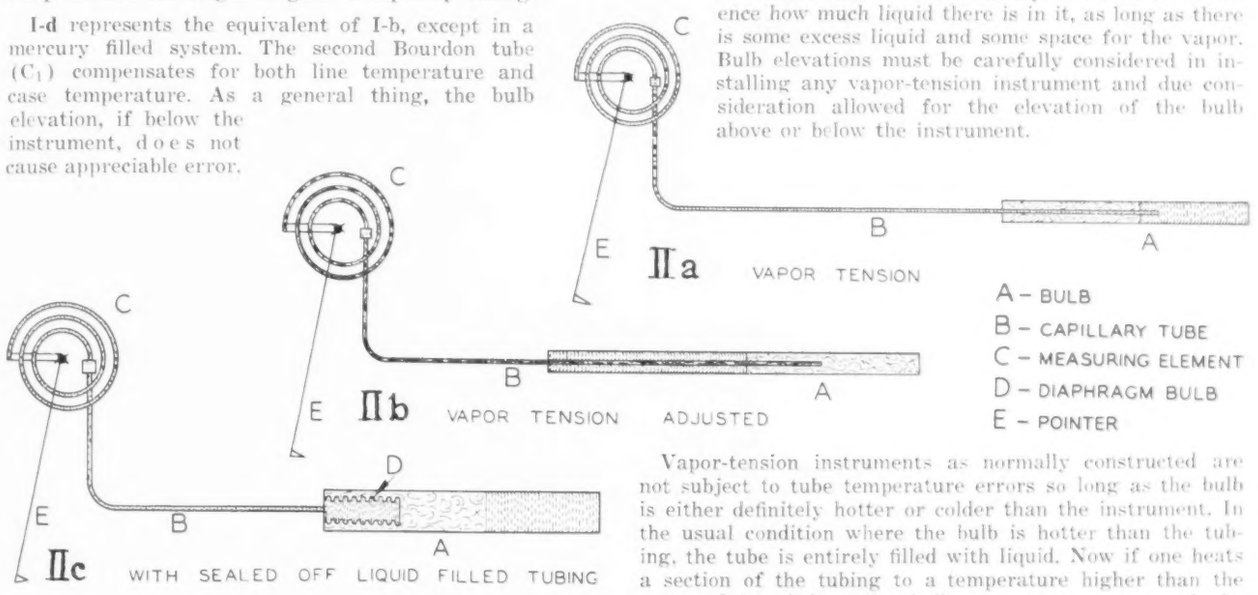
By L. G. BEAN

The Bristol Co., Waterbury, Conn.

urally utilizes an extremely stiff spring and gives an element with a high amount of power. Of course, with the utilization of mercury, steel parts are necessary, which calls for steel inner bulb, tubing and Bourdon tube, as well as welded construction. By establishing a high initial pressure, errors due to bulb elevation are lessened.

I-c represents a mercury-filled thermometer with an extra Bourdon spring connected to the system in parallel with the actuating spring, but not an operating part of the mechanism. The purpose of the second spring is to absorb one-half of the mercury which otherwise would be forced into the operating spring because of excessive line temperature changes, thus cutting the line error in half. If necessary, additional dummy springs may be added. This gives a partial compensation for longer lengths of capillary tubing.

I-d represents the equivalent of I-b, except in a mercury filled system. The second Bourdon tube (C_1) compensates for both line temperature and case temperature. As a general thing, the bulb elevation, if below the instrument, does not cause appreciable error.



I-e represents another form of mercury-filled thermometer system which is considerably used. To illustrate this, the tubing has been unduly enlarged out of proportion in the sketch, so as to show the invar wire which is drawn through the bore of the capillary. This greatly reduces its volume and (by correctly proportioning the area of the invar to the area of the capillary bore) the differential of the expansion between the two can be made approximately equal to that of the mercury in the capillary, the theory being that the capillary bore will expand with an increase of temperature more than the invar and thus the capillary will tend to be self-compensating.

All liquid-filled thermometers are theoretically subject to bulb elevation errors if used at other elevations than calibrated for, but these are minimized by using higher operating pressures. The mercury-filled thermometers may cover ranges from —40 to roughly 1000°, whereas the liquid- or alcohol-filled are generally limited to ranges from —40 to around 300°.

II—VAPOR-TENSION

II-a. Vapor-tension instruments, due to their fundamental simplicity, have also found a definite field of use. They are practically all characterized by a relatively high increasing scale chart. This is due to their basic principle of operation, which consists of filling the moving element, capillary and part of the bulb with a volatile liquid after the system has been evacuated. As temperature is applied to the bulb, this liquid is vaporized, producing a pressure in the same. A definite relation exists between the liquid temperature and the vapor pressure above the liquid, as long as the bulb always contains some liquid. This vapor pressure varies, of course, with the type of medium being used. Such instruments naturally start at a zero pressure and build up to some value; and, their curves not being straight lines, it is essential to pick a suitable chart for the range involved, as naturally one gets an open scale at the upper part of the range which is the section of the scale that should be used.

II-b shows a slightly modified form of the normal vapor-tension instrument which is used where long lengths of tubing are encountered where the bulb may be at lower temperatures than the tubing. It is termed an "adjusted vapor tension instrument." It practically consists merely in slightly enlarging the bulb of the instrument so that there is additional room in the bulb for the liquid in the tube when it vaporizes. Good results are obtained with such an instrument as long as there always is some liquid in the bulb and yet it is never full. In other words, as the name "vapor tension" implies, there must always be a surface of liquid in such a bulb and theoretically it makes no difference how much liquid there is in it, as long as there is some excess liquid and some space for the vapor. Bulb elevations must be carefully considered in installing any vapor-tension instrument and due consideration allowed for the elevation of the bulb above or below the instrument.

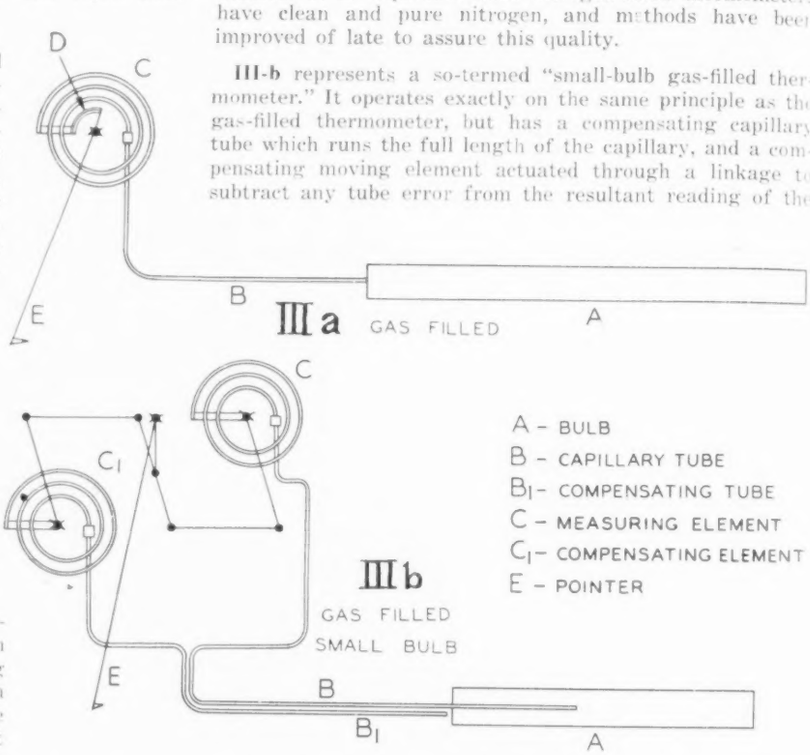
Vapor-tension instruments as normally constructed are not subject to tube temperature errors so long as the bulb is either definitely hotter or colder than the instrument. In the usual condition where the bulb is hotter than the tubing, the tube is entirely filled with liquid. Now if one heats a section of the tubing to a temperature higher than the rest and just below the bulb temperature, some of the liquid will be expanded back into the bulb. This will not affect the reading. If that section of tubing is further heated so that it is hotter than the bulb temperature, then the liquid in the tube at that section will be vaporized, forcing some more of the liquid back into the bulb. This may give an erratic reading momentarily on the chart, but will immediately reach a stable condition. In ordinary vapor-tension instruments, the bulb needs only to be large enough to take care of expansion and contraction of the liquid in the tube due to ambient temperatures along the tube and yet never be full or empty.

II-c represents a combination of vapor-tension and liquid-filled systems in that we have the moving element and capillary tube and a bellows (D) completely filled with the liquid. Bulb A is evacuated and partly filled with a volatile liquid. The result is that as temperature is applied to the bulb, the liquid vaporizes and compresses diaphragm D. It is in practice self-compensating, by the fact that any temperature changes along the tubing cause diaphragm D to take a slightly different position but does not affect the vapor pressure in A, vapor pressure being dependent upon vapor tension and not upon the volume of bulb A. Such a construction is ideally adapted for applications where vapor-tension ranges are desired, but where long tubings with variations in temperature above and below the bulb temperature are

encountered. It avoids the erratic action which a vapor tension gives when the tube temperature is caused to go above or below the bulb temperature. As evident, it combines certain of the advantages of vapor-tension and liquid-filled system.

III—GAS-FILLED

III-a represents the ordinary gas-filled thermometer. Such systems are first carefully evacuated and then filled at atmospheric temperature with nitrogen at approximately atmospheric pressure. This means that the Bourdon tube then starts, on an instrument starting at atmospheric temperature or below, from an atmospheric temperature and builds up to some predetermined pressure. The law of theoretical expansion, of course, is a straight-line linear function directly in accordance with Boyle's law. Such instruments can be made with a fractional scale, although in general practice they are not recommended of more than 50% fractional range, unless some special tube arrangement is provided for it. The range limitations are broad, being capable of going to 40° or 50° below zero to 1000° or 1200°. The upper limit is more dependent upon the physical bulb structure than upon the filling medium. Tube compensation is provided merely by keeping the bulb volume large in proportion to the total tube and moving element volume. A ratio of not less than 40:1 is considered good practice. While the torque of the gas-filled instrument is not as high as some other instruments, it can be made ample for most industrial uses, particularly if properly designed light linkages are used. Due to the fact that nitrogen is an inert gas, copper bulbs can be used in all but the highest ranges or where subject to chemical attack and can be made relatively sensitive. Also, the fact that extremely high pressures are not encountered means that a good grade of non-ferrous moving elements can be utilized. It is important that nitrogen-filled thermometers have clean and pure nitrogen, and methods have been improved of late to assure this quality.

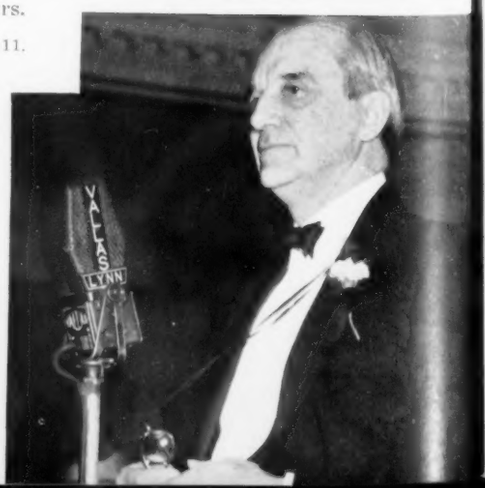


III-b represents a so-termed "small-bulb gas-filled thermometer." It operates exactly on the same principle as the gas-filled thermometer, but has a compensating capillary tube which runs the full length of the capillary, and a compensating moving element actuated through a linkage to subtract any tube error from the resultant reading of the system, which combines both the capillary tube and the bulb temperature. While theoretically probably not a perfect compensator, it makes a satisfactory means of compensation for industrial work and is being quite widely used.

G-E Meter Manufacture Milestone

FIFTY years ago commercial production of watthour meters was begun at West Lynn, Mass., by Professor Elihu Thomson.* On Oct. 4 the fiftieth anniversary of this beginning—and the completion of the twenty-millionth meter—were signalized together by impressive celebrations. More than 500 personages attended the golden jubilee dinner; more than 5000 persons paraded; more than 30,000 people jammed the West Lynn municipal stadium. *Top left*—Ass't Mgr. N. M. DuChemin with Elihu Thomson's Meter No. 1 and Meter No. 20,000,000. *Lower left*—"King Volta" and "Queen Electra" bid their "page boys" present the twenty-millionth meter to the utilities industry. *Below*—F. C. Vaughen, Mgr. of G-E's Meter Div., who made the official presentation. *Top right*—Dr. Alex Dow, Pres. of Detroit Edison, who accepted the twenty-millionth meter, being congratulated by Gov. Saltonstall of Massachusetts. *Lower right*—Owen D. Young pays tribute to the early pioneers.

*See obituary biography, *Instruments*, April 1937, page 111.



Pendulum and "Cloudburst" Methods of Measuring and Testing Hardness

Concluded from September issue

By S. R. WILLIAMS
Professor of Physics, Amherst College

The Kusnezow Pendulum Hardness Tester. This pendulum was described first by Kusnezow[4], but inasmuch as the pendulum was used later in connection with some important tests on surface hardness by Rehbinder[5], the latter's slightly modified form will be discussed.

Fig. 205 shows a cross-sectional view of the pendulum and Fig. 206 shows it on its operating stand. As indicated in Fig. 205 the pendulum is supported on the surface of the test material by means of two hard steel

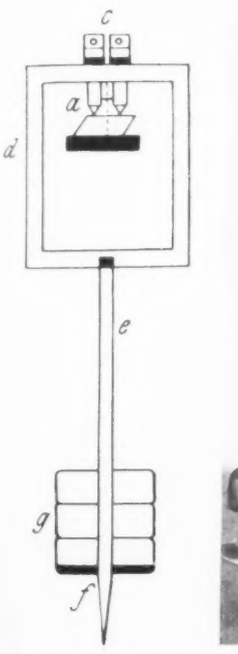


Fig. 205. Cross-section of Kusnezow's Pendulum Hardness Tester.

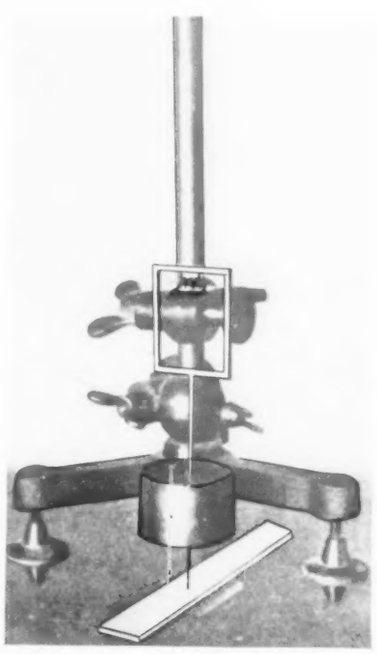


Fig. 206. The Kusnezow Pendulum Hardness Tester mounted on its operating stand.

points, (a). (Steel balls may be used in place of the hard steel points for certain substances to be tested.) In either case the steel balls or the points serve in place of a knife edge from which the pendulum might have been suspended. As the pendulum swings back and forth, the points penetrate into the surface of the test piece. If the material is a brittle crystal, a crystalline powder will form in the depressions made by the steel points. Under certain conditions one may hear the grinding process going on. If the substance under test is plastic, cold working of the test piece will occur under the points. Actually, a new surface is produced under the steel points as the pendulum rocks to and fro. The energy thus used up in crushing the brittle crystal into powder or cold working the plastic substances under the steel points has been at the expense of the energy of vibration. The more powder formed or the more quickly the cold working is done, the sooner will the oscillations of the pendulum damp down and finally come to rest.

When Kusnezow devised and used this instrument, he made the length of time required by a material to decrease the initial amplitude of vibration, A_o, down to a determined value, A, serve as a hardness index. Rehbinder, on the other hand, followed continuously the decrease in amplitude with time and obtained curves similar to those shown in Fig. 207. On drawing the sub-

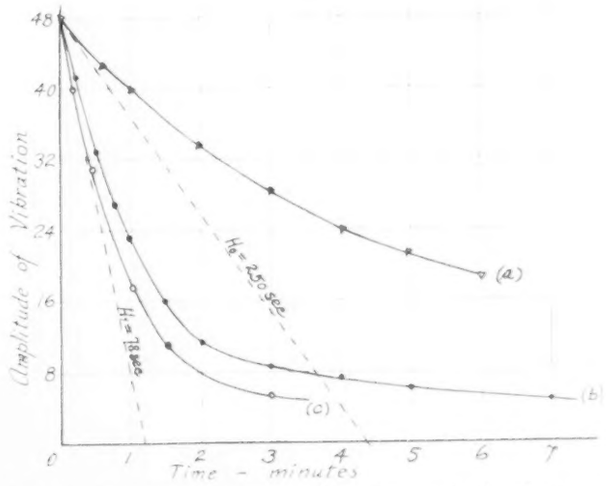


Fig. 207. Showing the rate at which the amplitude of swing of the Kusnezow Pendulum Hardness Tester varies with the time.

tangents to these curves at their initial points, *i.e.*, when $t = 0$, then the values of the intercepts on the time axis became the value which Rehbinder used as a hardness number. In Fig. 207, Rehbinder's definition of hardness may be represented by the equation:

$$H = -\frac{A_o}{\left(\frac{dA}{dt}\right)_o} = t_o$$

For the simplest case

$$\frac{dH}{dt} = 0;$$

and

$$\frac{1}{A}\frac{dA}{dt} = \text{constant};$$

$$\log A = \log A_o - \left(\frac{1}{H}\right) t$$

$$A = A_o e^{-\frac{t}{H}}$$

Rehbinder then proceeds to apply this definition of the H values to a study of the way in which, as certain solutions are added to the surface of the crystal being tested, these solutions decrease the hardness as measured by Kusnezow's pendulum. Thus in Fig. 207, curve (a) indicates the way in which the amplitudes of the pendulum decreased as time progressed. This is under the condition that the surface of the crystal

[4] W. D. Kusnezow, The Pendulum Sclerometer, *Journal für angewandte Physik* (russ) Vol. 6, 1931, pages 33-35.
[5] P. Rehbinder, Verminderung der Ritzhärte bei Adsorption grenzflächenaktiver Stoffe, *Zeitschrift für Physik*, Vol. 72, 1931, pages 191-205.

($CaSO_4 2H_2O$) has a coating of paraffin oil on it. In spite of the high viscosity of the paraffin oil the same curve is obtained with the pendulum vibrating on a clean surface of the crystal. However, if paraffin oil and oleic acid are mixed with additions of 0.1% to 0.4% of oleic acid to the paraffin oil there is a marked decrease in the hardness number given by the Kuznezow pendulum hardness tester as the concentration increases. This is shown in the curves (a), (b) and (c), Fig. 207. The oleic acid in solution with the paraffin oil acts as a hardness depresser. When these solutions cover the surface of the crystal tested there is present an absorption layer which can be demonstrated and whose surface energy can be measured. Rehbinder seemed to indicate in his paper that in this surface energy was to be found the cause for the decrease in the hardness as the concentration increased. Not only did Rehbinder study a number of different crystals, but also a number of different solutions. In addition he tested a large number of metals and found that their relative hardness numbers compared favorably with relative values given by other methods. It should also be stated that the load carried on the pendulum varied from 374 g. for graphite up to 5000 g. for glass. For the crystal, ($CaSO_4 2H_2O$), a load of 1023 g. was imposed.

The author believes that Rehbinder has initiated an important series of researches which it would be desirable to continue. Such a series of experiments would need (1) to have a great deal of attention paid to the manner in which the points (a) in Fig. 205, behaved as the points ground into the surface of the material. The steel points themselves must not change form during the tests. (2) A study should be made of the distinction which this hardness tester would make between brittle and plastic bodies. (3) One should compare the results of this pendulum with those of the Herbert pendulum on the same specimens.

Recently, Wesley has studied the hardness of nickel electrodeposits and finds[6] that such electrolytically deposited metals (notably nickel) can be prepared with greater hardness than can be obtained from the same metal in wrought forms. Why? Is it due to the hydrogen as a hydrite or in solid solution? Is it due to the fact that the hardness which accompanies fine grain size is caused by interference with crystal growth exerted by colloidal nickel hydroxide or other basic compounds which are precipitated in the film of the solution on the cathode surface and are occluded in the deposit? Are there hardness augmenters as there are hardness depressers which Rehbinder studied? In the case of electrodeposits are there at each surface laid down certain non-metallic particles in a critical state of dispersion which might interfere with slip and thus cause hardness of the type developed in precipitation-hardened alloys, such as duralumin?

The experiments of Rehbinder and Wesley seem to offer a fruitful field of research. Instead of Rehbinder's pendulum it would be of interest to test these hardness depressers by means of the Microcharacter.

In an attempt to study surface hardness by means of the newer hardness testers such as the Rockwell superficial hardness tester it would appear that such questions as Rehbinder and Wesley have raised would have most important bearings on the hardness numbers given by such superficial hardness testers.

THE CLOUDBURST PROCESS

About 1923 it was discovered that the hardest steel, such as is used in automobile gears, was capable of being super-hardened by cold work. Just the play of the gear teeth on each other increased their superficial hardness. This led Herbert to the invention of the so-called "Cloudburst Process."[8] Whereas the continual working of the gear teeth on each other led to deformation, the cloudburst method does not deform. This method provides two distinct processes which are of value in hardness testing and super-hardening of metals.

1. It tests the uniformity of hardness of the *entire* surface of the specimen and marks all spots below the standard hardness. It provides for the testing of hard-

[6]W. A. Wesley, Physical Properties and Uses of Heavy Nickel Deposits. *Metal Industry*, Vol. 36, 1938, pages 385-388.

[7]D. J. Macnaughtan, G. E. Gardam and R. A. F. Hammond, The Influence of Composition and Acidity of the Electrolyte on the Characteristics of Nickel Deposits. *Transactions Faraday Society*, Vol. 29, 1933, pages 729-754.

[8]E. G. Herbert, Cloudburst Process of Hardness Testing and Hardening. *Transactions American Society for Steel Treating*, Vol. 16, 1929, pages 77-96.

Anon, The Herbert Cloudburst Production Hardness Tester. *American Machinist*, Vol. 69, 1928, pages 411-412.

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ness on a production basis without marking or injuring properly hardened specimens.

2. It is a cheap and efficient means for super-hardening the surface of metal objects without affecting the polish.

Fig. 208 shows a 12″ motor-driven "Cloudburst" machine. There are also hand-driven machines. These devices subject the surface of a material to a rain of hard steel balls falling from a known and readily adjustable height. The 12″ machine is rated to deliver 500000 blows per minute, using 250000 balls, $\frac{1}{8}$″ in diameter. As these steel balls patter down on a given surface, their impacts will produce little imprints if the substance is too soft. The whole surface will show at once whether there is uniformity of hardening or not. If it is desired not to mark the surface, the height of fall

Fig. 208. The Cloudburst Machine.

Fig. 209. A tool-steel disk which was hardened and then subjected to the cloudburst test.

can be regulated so that no marking occurs. On the other hand, when these steel balls fall from a considerable height, each impact is the blow of a tiny hammer, and in a few moments' time the surface has been cold-worked by the process of hammering and a super-hardened surface results. Fig. 209 shows clearly what the cloudburst process reveals after the bombardment has taken place. Fig. 209 also shows the indentation test superimposed upon the cloudburst test. One is impressed with the great impetus Herbert has given to the problem of hardness testing and hardening processes by the discoveries and inventions he has made in these fields.

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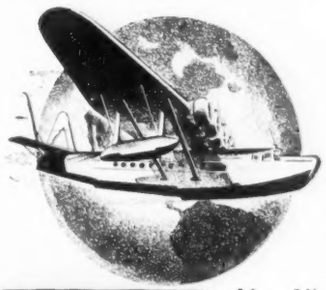
See Page 293

RESISTORS



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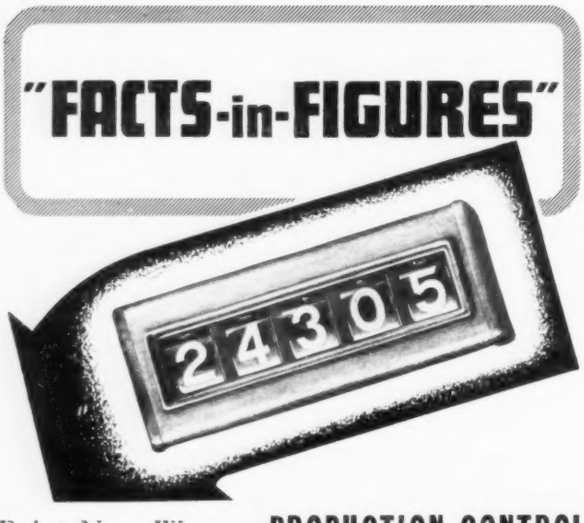

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Instrumentation at Irvin Works

(Continued from page 295)

bath temperatures are automatically controlled within 10°F and recording thermometer charts record the pickling cycles, which are worked out to fit the concentration of the acid in the tanks. Pressure on the breaker rolls at the uncoilers is also regulated to assure that the strip enters the pickling lines in the best condition for efficient treatment.

In the cold reduction department, attention is paid to the surface finish of the product as well as to its physical properties, size and gage. A constant scleroscope check is kept on the hardness of the rolls, which are changed as required to maintain the close range of hardness found to be most efficient in rolling the product demanded. Quality inspectors are on duty at the three cold mills at all times, constantly checking the finish, gage and contour of the strip as it leaves the mills.

Complete instrumentation at the panel boards in the cold reduction department allows the mill operators to balance and control the screwdowns and roll pressures on all stands, roll speeds, and the tension at the entering and discharge ends of the mills as well as between stands. Flying micrometers keep the operators and inspectors advised at all times as to the gage of the product leaving the mills. Strain gages built into the mill housings facilitate adjusting roll pressures.

Cold-reduced strip from the 5-stand 42″ tandem cold mill is ordinarily transferred to the tin plate division. Material from the 3-stand 84″ tandem cold mill goes to the cold reduced strip and sheet finishing department. The 54″ reversing cold mill supplies either the tin mill or the cold mill finishing department. Inspection becomes increasingly severe as the product approaches the final processing operations. Coiled strip which passes the cold mill inspectors moves on through the electrolytic cleaning lines when it is to be used for tin plate. Here recording, indicating and control instruments are installed to maintain the desired current density, strip speed and tension on the strip. Inspectors check these factors as well as the condition of the cleaned surface.

Coil annealing temperatures are raised, held and lowered, in accord with established schedules to give the desired structure. All pyrometers are checked at least every other day, and compared with a standard at least once every two weeks. To assure definite control of cycles, recording pyrometers are installed throughout the coil annealing department. Each annealing furnace base will carry 16 coils under 8 hoods and a thermocouple is installed under each individual hood even though the entire group is under a single heating cover. Coil temperatures must be held within a ± 10°F. temperature range. Periodic checks are made on the coke oven gas used for heating the furnaces and on the DX gas used under the hoods covering the coils.

To check the annealing and the response of the steel to the specified treatment, the metallurgical department tests for stiffness, Rockwell hardness, ductility and structure. Every coil is checked, the hardness range varying according to the use to be made of the finished product.

Ductility of the product is checked when necessary by Olsen and tensile tests. Further, in order to guarantee the stiffness required on certain tin-plate orders, the metallurgical department makes daily checks on the hardness of samples taken from the assorting room, to make sure that every shipment comes within the hardness range desired.

At the tin mill shearing lines (which operate at strip speeds up to 350 feet per minute) flying micrometers operating through delay relays automatically assort the plate by gage, holding the pack within the allowable tolerance. Even after passing the mechanical assorters, the sheared plate is inspected for gage, surface, and squareness.

In the white pickle room, inspectors check the temperature of the bath, concentration of acid and activity of the bath every turn in the chemical laboratory adjoining the tin mill. This laboratory also checks the tin-plate every turn as it comes from the tinning machines to determine

the weight of the coating, using the Sellers test. Certain tin plate shipments are classified as to corrosion resistance by the hydrogen evolution test for use in dry pack, vegetable, fruit or special product canning.

After the finished tin plate has passed the assorting room inspections, ten plates are taken at random by the metallurgical department from each temper rolling for a final check. These plates are subjected to the Rockwell hardness test, the Olsen test for ductility, and the Schopper test for stiffness, and at intervals to a tensile strength test as well. Accuracy of the base weight is, of course, checked as a matter of routine and fluting tests are run on certain classes of the finished product.

Cold reduction involves complicated strip and sheet rolling, and since good surface depends on both the hot and cold work, close inspection both before and after cold rolling becomes increasingly important. Practically all the product from the 3-stand 84″ tandem cold mill as well as a substantial proportion of that from the 54″ reversing cold mill is delivered to the sheet annealing department for annealing prior to cold finishing. The packs are annealed in a controlled atmosphere under hoods. Their size and mass make particular care essential in time and temperature control.

Each annealing furnace is equipped with a two-point pyrometer. One thermocouple is inserted in the top edge of the pack for control of maximum temperature within 10°F.; the other is centrally located at the base of the pack for control of the soaking time; the recorder chart serves as a permanent record subject to study.

In order to maintain close control of sheet quality up to the very last, normal practice at the Irvin Works is to require that all temper rolling be done just prior to shipment. Accelerated aging tests, however, are made at the cold strip laboratory to determine the effect of a possible three-month storage period at the customer's plant. Duplicate specimens are kept for re-checking.

Routine practice calls for Rockwell hardness and Olsen ductility tests on practically all sheet or strip after temper rolling. Much of the product is subjected to a bulge test, which shows how the surface of the sheet will appear after drawing and helps determine the proper roll finish. Pull tests on longitudinal samples show up any light coil breaks if they occur. Strain tests on notched samples indicate whether or not the sheet has been temper rolled sufficiently to avoid the occurrence of stretcher strains in subsequent forming operations.

All tests are made on material known to represent the most difficult material to process; care is exercised to select stock shipped for special deep drawing operations. In certain cases every sheet in a pack is gaged immediately after temper rolling. Further, temper rolling schedules are worked out to hold the hardness range within narrow limits.

Four laboratories are located in the mill, convenient to the departments which they serve. There is also a main laboratory for research and development, for the heavy tests such as tensile strength and for re-checking the results reported from the shop laboratories. Beside these five, a special enameling laboratory is provided for investigating the effect of sheet surface on the adherence of porcelain enamel. Complete facilities for pickling, together with an enameling pot and furnace, are included, with special enamel adherence testing machines. Complete grinding and analytical equipment is also provided.

The research and development laboratories maintain close contact with the field so as to gain a full appreciation of the customers' problems. Experience indicates that frequently a minor change in processing, either in the steel mill or in the customers' plant, will solve what apparently is a major problem. Further, by studying industrial trends in design and manufacture, the sheet producer is able to present a product already adapted to a need when it arises. Quality control is thus extended beyond the steel mill, serving not only the steel producer and product manufacturer, but also the ultimate consumer.

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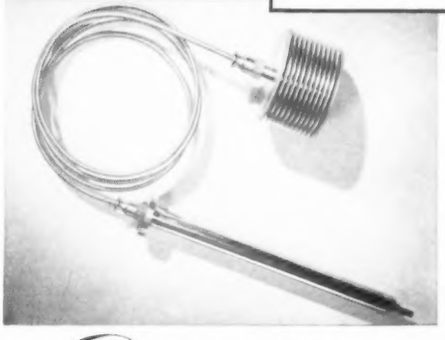

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INSTRUMENTS' BOOK SHELF

Spectroscopy in Science and Industry —Proceedings of the Fifth Summer Conference on Spectroscopy and its Applications. Foreword by GEORGE R. HARRISON. John Wiley & Sons, Inc., New York, 1938. Paper, $7\frac{1}{2} \times 10$ inches, vii + 134 pages. Price $3.00.

Those privileged to attend these conferences will wish copies of this publication which records the salient features of the papers presented in 1937. The papers are, for the most part, presented by those who have found solutions for particular problems. This report gives a résumé of much of the progress which has been made in spectrochemical analysis during the preceding year or so, with each phase of the subject handled by someone who is experienced in that particular branch. Anyone with an important development to report is asked to speak; those having interesting unsolved problems are urged to attend.

The thirty-odd papers deal with: Absorption spectra; emission spectra; the application of spectroscopy to the analysis of steel—and of tissue; the state of wave-length tables; the availability of high-purity metals; useful accessories; methods of teaching. The report not only covers current developments in spectrochemical analysis, but indicates where and by whom the work is being done. All analysts should have access to this small but meaty volume.

—KELVIN BURNS, *Astronomer, Allegheny Observatory, Pittsburgh.* (7.5)

Spectrochemical Analysis in 1938. By F. TWYMAN, Adam Hilger, Ltd., London, 1938. Paper, $6 \times 9\frac{1}{2}$ inches, 68 pages. Price 4s/6d.

This is a companion book to "Spectrochemical Abstracts 1933-37. The reader is assumed to be aware of the state of the art of spectrochemical analysis at the end of 1933. This book, together with the abstracts, aims to show what has been added to the knowledge and technique of the subject during the past five years. The writer is in a position to speak with authority when he describes in detail what he considers to be the best technique at the present time for routine metallurgical analysis. In this connection the use of the microphotometer is explained so fully that a beginner may be able to use this instrument for quantitative work. The use of sparking circuits is treated at length. The chief causes of discrepancies between chemical and spectrochemical analyses are considered. In a chapter by A. C. Candler the elements of atomic spectrum theory are treated in simple style, easily understood by the layman, yet sufficiently complete for the purposes of chemical analysis.

—KELVIN BURNS, *Astronomer, Allegheny Observatory, Pittsburgh.* (7.5)

Mercury Arcs. By F. J. TEAGO and J. F. GILL. Chemical Publishing Co. of New York, New York, 1936. Cloth, $4\frac{1}{4} \times 6\frac{3}{4}$ inches, 104 pages. Price $1.25.

This book forms the basis of a course of design lectures on the mercury arc given in the Electrical Engineering Department, University of Liverpool. The subjects covered are: Constructural Details; Grid Control of Voltage; Grid Control of Current; Voltage Regulation; Current-Voltage Characteristics; Rectification, Inversion and Regeneration; Wave Form Analysis; Transformer Ratings; Power Factor; and Mathematics of Mercury Arcs.

—RICHARD RIMBACH (4)

Eigenschaften der Messgernete (Properties of Gages). Prepared by the Committee on Gaging of the Ausschuss fuer Wirtschaftliche Fertigung. Beuth-Verlag, Berlin SW 19, 1936. Paper, $6 \times 8\frac{1}{4}$ inches, 16 pages.

The committee defines properties for judging instruments for the measurement of length: Sensitivity, Limiting Valve, Errors, Variation and Range.

—RR (2.01)

The Chemical Formulary, Vol. IV. H. BENNETT, Editor-in-chief. xii + 572 pages + 33 pages of chemical directory + 32 pages of index. The Chemical Publishing Co. of New York, Inc., 148 Lafayette St., New York, 1939. Price $6.00.

This book is the fourth volume of the Chemical Formulary series and contains new and additional formulae gathered during the past year.

A 15-page introduction for the benefit of beginners in the art of compounding gives wholesome advice on the handling of chemicals as well as methods of compounding; and includes numerous well-discussed examples of familiar products.

The classifications treated are: adhesives, beverages, liquors, flavors, cosmetics, drugs, emulsions, farm and garden specialties, food products, inks, leather, skins and furs, materials of construction, paints, varnishes and lacquers, paper, photography, plating, polishes and abrasives, pyrotechnics, rubber, resins, plastics and waxes, soap and cleansers, textiles and fibres, and miscellaneous.

In the back of the book are a list of trade-name chemicals arranged alphabetically, a list of suppliers of tradename chemicals, a rather complete domestic list of where to buy the lesser-known materials, a foreign list of chemical suppliers, and a comprehensive index. Following the index is a list of about 250 books which will (or would) be of interest to a compounder.

On the whole, it is believed that Vol. IV is on a par with the previous volumes and is of distinct value to the experienced as well as the amateur compounder.

—M. G. MASTIN, *Westvaco Chlorine Products Co., So. Charleston, W. Va.* (8)

Die Gleichrichterschaltungen (Rectifier Connections). By W. SCHILLING. R. Oldenbourg, Munich, Germany, 1938. Cloth, $6\frac{1}{4} \times 9\frac{1}{2}$ inches. 279 pages. Price 17.50 RM.

This book treats the subject of rectifier connections through the use of equivalent circuits and step-by-step analysis. The method is graphical rather than mathematical, but in all cases a mathematical approach is indicated.

The first part of the book extends existing methods of treatment to the grid-controlled single-phase circuit. This is followed by a discussion of the fundamentals of a-c. polyphase circuits as applied to rectifiers. The remainder of the volume is devoted to various circuits used in practice, both without and with grid control. The usual assumptions of negligible transformer resistance and highly inductive load are employed. Several commonly-used circuits are not covered in detail on the ground that their treatment involves nothing fundamentally new.

The unsymmetrical magnetization of a transformer supplying a single-phase or half-wave rectifier is discussed at some length. This topic is all too frequently casually dismissed without explanation.

The behavior of most of the circuits considered is investigated for all loads up to short circuit. Operation beyond the normal load range is of great importance, hence this portion of the treatment is welcome.

An appendix contains tables and curves which are useful when making numerical calculations.

The author proposes to extend his work to cover inverter and frequency changer circuits in a subsequent book.

—A. J. MASLIN, *Design Engineer, Westinghouse Elec. & Mfg. Co., Sharon, Pa.* (4.2 & 5.4)

Grundlagen für die Messung von Stirnrädern mit gerader Evolventenverzahnung (Measurement of Spur Gears with Straight Involute Teeth). By G. BERNDT. Verlag Julius Springer, Berlin, 1938. Paper, $6\frac{1}{2} \times 9\frac{1}{2}$ inches, 155 pages.

A mathematical treatment.—RR (11)

Die Fluoreszenzanalyse in der Mikrochemie (Fluorescence Analysis in Microchemistry). By MAX HAITINGER. Emil Haim & Co., Vienna and Leipzig, 1937. Paper, $6\frac{3}{4} \times 9\frac{1}{2}$ inches, 102 pages. Price 8 RM.

This is one of a series of monographs on Microchemistry by the same publisher. The subject of fluorescence is treated as a tool of scientific research. The technique and application of fluorescence analysis in chemistry and mineralogy are fully covered. The fluorescence phenomena of individual chemical compounds are described insofar as they show the relations among definite groups, and especially as they may be of importance in the further development of this tool. The methods of detection in which non-fluorescent substances are converted into fluorescing ones by chemical means are fully described. The author stresses the importance of exact color determination of light sources and gives the necessary instructions. Directions for accurate measurement of hue, saturation and brightness of fluorescence are included, as well as the application of the data in determining the concentration of fluorescing substances in liquids, and in studies of hydrogen-ion concentration. The technique of macroscopic and microscopic fluorescence analysis is thoroughly covered, including the application for detecting traces of substances and the limits of sensitiveness possible by this method. Microscopic fluorescence reactions on plant and animal cells are also described. The literature of the subject is thoroughly covered by copious bibligraphies at the end of each chapter, with a total of 795 references, plus an appendix giving brief reviews of 38 papers which appeared while the book was in press. Seven tables of useful physical data are included. The book has good subject and author indexes.

—M. W. WEISS (8)

Thermodynamics, Fluid Flow, and Heat Transmission. By HUBER O. CROFT, McGraw-Hill Book Co., New York, 1938. Cloth, $6 \times 9\frac{1}{4}$ inches, xi + 312 pages. Price $3.50.

As the author points out in his preface, the title and subject matter of this book refer to material which is usually separated into three distinct subjects, to each of which might well be devoted a whole book in itself. Here, however, the most important parts of the three topics, thermodynamics, fluid flow, and heat transmission, are combined and unified into a single condensed treatment. While such a plan necessarily requires the omission of a number of specialized items discussed in individual treatises on each of the topics, the student and general reader will undoubtedly learn more by the study of this single text than by distributing the same amount of time over the study of separate and more specialized books.

The book consists of eleven chapters and several tables of appendix. In the first the definition of the terms and quantities used throughout the rest of the text are explicitly defined, and their units stated. The second outlines the principles of dimensional analysis, and gives a number of examples of its application to practical engineering problems. The next four chapters deal with thermodynamics and the applications of the first two laws to cyclic processes and heat balance problems, the treatment following rather conventional engineering outlines. The two following chapters are devoted to the study of fluid flow, the first dealing more with the physical and analytical features of flow systems, and the second with principles and apparatus for flow measurements. The subject of heat transmission is then taken up in a 68-page chapter, treatments being given both of the strictly physical theories pertaining to the subject and of those

Continued on page 308

NEW LITERATURE

G384 **Transformers.** Bulletin No. BC 1, 8½" × 11", 64 pages, covers complete line including Linear Standard Audio, Varimatch and Varitran transformers and communication equalizers and filters, etc. United Transformer Corp., 150 Varick St., New York City.

G385 **Optical Pyrometer.** Catalog N-3310, 7-4" × 10½", 16 pages, describes potentiometer type which measures industrial temperatures. Calibration is in temperature degrees. Both potentiometer and telescope are housed in strong, lightweight alloy castings. Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.

G386 **Mercury Switches.** Bulletins No. 503 and 504, 8½" × 11", 12 pages combined, describes technical specifications, operating characteristics and application data of "Durakool" switches. Durakool Inc., Elkhart, Indiana.

G387 **"Gyrometer."** Bulletin No. 120, 8½" × 11", 4 pages, describes applications and specifications of instrument for measurement of water, sewage, air, gas, etc. Simplex Valve & Meter Co., 68th & Upland Sts., Philadelphia, Pa.

G388 **Porcelain Filters.** Bulletin No. 909, 8½" × 11", 2 pages, describes standard types of filters with ability to retain fine-grained materials. Material from which filters are constructed is resistant to chemical reagents. The Selas Co., Ceramic Engineering Div., 18th St. at Indiana Ave., Philadelphia, Pa.

G389 **Testing Instruments.** Pages 19 and 20, 8½" × 10¾", describe "Testlite" for instantaneous test of cables, starter and battery; also listed are voltmeter and other battery service equipment. Allen Electric & Equipment Co., Kalamazoo, Mich.

G390 **Electric Static Pressure Regulator.** Sheet, 8" × 10", 2 pages, describes Type P212A regulator designed for use in conjunction with "Series 60 Floating" device—such as a motorized damper, to control the static pressure in the discharge duct of a fan system, to control the overfire draft in a combustion chamber or similar applications where definite static pressure conditions are to be maintained. Minneapolis-Honeywell Regulator Co., 2950 Fourth Ave. South, Minneapolis, Minn.

G391 **Fire Protection.** Form 5-39-27, 8½" × 11", 1 page, describes and illustrates "Fyre Scout" kit with detector heads. Fire gong operates on 6 volt dry cells or a heavy-duty bell-ringing transformer. Tecnical Appliance Co., 17 East 16th St., New York City.

G392 **Rate of Flow Indicator.** Bulletin B 98-I, 8½" × 11", 2 pages, describes and illustrates No. 98 indicator of the differential pressure type which may be used to indicate rates of flow through a pipe line of steam, liquids or gases. Morey and Jones, Ltd., 922 South Hemlock St., Los Angeles, Calif.

G393 **Unimeter and A-C Bridge.** Data Sheets Nos. 220 and 230, 8½" × 11", each 2 pages, describe Unimeter which presents television ranges, compensates temperature and has super safe design; and A-C Bridge featuring new "Leakage-Per-MF." scale and rejection to U. S. Navy specifications. The Clough-Brengle Co., 5501 South Broadway, Chicago, Ill.

G394 **Electro-Chemical Feed.** Bulletin No. 2233, 8½" × 11", 8 pages, describes features, construction details and specifications of feeder used for chemical suspensions such as lime, or chemical solutions such as soda ash and coagulant. The Permutit Co., 330 West 42nd St., New York City.

G395 **Electric Flow Meter.** Bulletin, 8¾" × 11", 4 pages, describes meter using null or zero-balance method in measurement and provides ample operating power throughout the scale range. Cochrane Corp., 18th St. & Allegheny Ave., Philadelphia, Pa.

G396 **"The Hydromike."** Vol. 3, No. 1, 8½" × 11", 4 pages, describes Stevens long distance recorder for switchboard mounting which measures water level to the nearest .01 foot; also article entitled "Errors in Float Operated Instruments." Leupold, Volpel & Co., 425 N. E. 70th Ave., Portland, Oregon.

G397 **Surface Temperature Pyrometer.** Bulletin No. 2850-I, 8½" × 11", 4 pages, describes and illustrates new instrument for readings up to 1200°F., featuring new fan shaped dial, flexible, adjustable thermocouple joint, interchangeable thermocouple and handle that may be screwed in either bottom or back of instrument. Wheelco Instruments Co., 1929-33 So. Halsted St., Chicago, Ill.

G398 **Flame Detector.** Bulletin No. 210, 7¾" × 10½", 8 pages, describes and illustrates construction and application of this device which affords protection against furnace explosion. Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio.

G399 **Thread Measuring Gages.** Catalog 39, 8½" × 11", 28 pages, describes and illustrates line of gages to measure and check pipe thread elements. General Engineering & Model Works, 421 Braddock Ave., Pittsburgh, Pa.

G400 **Heat Transfer.** Bulletin 305, 8½" × 11", 8 pages, contains a discussion on the subject of heat transfer as applied to constant temperature laboratory equipment. Precision Scientific Co., 1750 No. Springfield Ave., Chicago, Ill.

G401 **General Radio "Experimenter."** October 1939 issue, 8 pages, contains articles entitled "Radio-Frequency Distortion Measurements with an Audio-Frequency Analyzer", "Extending the Field of Application of the Variac" and "Revision of the Seashore Musical Talent Tests". General Radio Co., 30 State St., Cambridge, Mass.

G402 **Gear-Motors.** Bulletin 1480-I, 8½" × 11", 4 pages, gives dimensions, technical data and general description of capacitor type synchronous motors. The Holtzer-Cabot Electric Co., 125 Amory St., Boston, Mass.

G403 **Speed Reducer Motors.** Sheet, 8" × 10½", 2 pages, announces new line of built-in worm-gear motors for high torque, slow speed applications; also dimension sheet. Bodine Electric Co., 2254 West Ohio St., Chicago, Ill.

G404 **"Windowstat."** Bulletin No. W, 8½" × 11", 4 pages, describes and illustrates device for automatic protection against condensation on windows. Julien P. Friez & Sons, Baltimore St. & Central Ave., Baltimore, Md.

G405 **Condensers, Resistors and Test Instruments.** 1939-40 Catalog, 8½" × 11", 28 pages, describes and illustrates complete line of condensers, resistors, capacity and resistance bridge and the L-C checker. Aerovox Corp., New Bedford, Mass.

G406 **Thermometers and Pressure Gages.** Booklet No. 2-17, 7⅞" × 10½", 8 pages, describes the vapor-actuated, gas-actuated and mercury-actuated types of thermometers. Indicating and one, two and three pen recording models are illustrated. Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa.

G407 **"Technical Announcer."** No. 39-102, 7⅞" × 8⅜", 8 pages, contains feature article entitled "Polarized Light Test Makes Machines Safer" and descriptions of water and sewage laboratory mixer, gas analysis apparatus, etc. Burrell Technical Supply Co., 1936-42 Fifth Ave., Pittsburgh, Pa.

G408 **Valve Pilot and Recording Speedometer.** 2 Bulletins, 8½" × 11", 4 pages each, describe and illustrate a combined speed and cut-off indicator and recorder for locomotives; also data on recording speedometer. Valve Pilot Corp., 230 Park Ave., New York City.

G409 **Portable Pyrometer.** Bulletin, 8½" × 11", 1 page, describes foundry type pyrometer, scale length of 4½", designed for measuring the temperature of molten metal in furnaces, ladles and crucibles. The Lewis Engineering Co., Naugatuck, Conn.

G410 **Test Equipment.** Catalog No. 121, 8½" × 11", 12 pages, covers complete line—tube testers, combination tube and set testers, Analyzer units, Signal Generator and special instruments. Radio City Products Co., 88 Park Pl., New York City.

G411 **Strip-Chart Recorder.** Bulletin GEA-3187A, 8" × 10½", 8 pages, describes and illustrates Type CF-1, portable inkless recorder for indoor or outdoor service. Weight 12 pounds. General Electric Co., Schenectady, N. Y.

G412 **Rotary Switches.** Catalog No. 9, 8½" × 11", 12 pages, describes instrument and control switches, flexible in design for standard or special requirements on circuits up to 600 volts; also data on indicating lamps. Roller-Smith Co., Bethlehem, Pa.

G413 **Quartz Crystals.** Catalog G-11, 8½" × 11", 16 pages, covers general communication frequency crystals, holders and ovens for frequencies from 20 kc. to 30 mc. Bliley Electric Co., Union Station Bldg., Erie, Pa.

G414 **Fuses, etc.** Catalog No. 8, 8½" × 11", 10 pages, describes and illustrates line of fuses, fuse mountings and clips and neon products. Littelfuse Inc., 4757 Ravenswood Ave., Chicago, Ill.

G415 **"The Ohmite News."** Aug.-Sept. 1939, 8½" × 11", 2 pages, contains feature article on new power tap switches; also description of "Corrib" corrugated ribbon resistors and other items. Ohmite Manufacturing Co., 4835-41 Flournoy St., Chicago, Ill.

G416 **Rotax Controllers.** Bulletin 184-3, 8½" × 11", 32 pages, describes controllers applicable to temperature, pressure, humidity, liquid level, flow and centralized control, also included are technical details of construction and operation and illustrations of typical installations. The Foxboro Co., 46 Neponset Ave., Foxboro, Mass.

G417 **Spectrophotometers.** Bulletin 142, 8½" × 11", 8 pages, describes and illustrates spectrophotometer assemblies for standardization, specification and analysis of color and colored products, for control of processes (chemical, oil, biological) in which color is an indication of purity and composition and for white-light photometry, nephelometry and turbidimetry. The Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.

G418 **Electric Thermometers and Pyrometers.** Catalog No. 1101 E, 8½" × 11", 32 pages, describes line of photoelectrically balanced recorders, indicators, controllers, recording controllers and resistance thermometers. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

G419 **Air Relay Transmission System.** Bulletin 259, 8½" × 11", 4 pages, describes and illustrates system for the Venturi Meter. Builders Iron Foundry, 9 Codding St., Providence, R. I.

G420 **Photoelasticity Polariscopes.** Bulletin 143, 8½" × 11", 4 pages, describes polariscopes for stress analysis, comprising two major units—the Polarizer and Analyzer Systems, each assembled on an individual double rod optical bench. The Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.

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INSTRUMENTS, Pittsburgh (NOVEMBER, 1939)

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which are essentially of an empirical nature. The engineering principles of the transport of solid particles in fluid streams are then discussed, and the book closes with a chapter giving a treatment of reciprocating centrifugal, rotary, and jet types of pumping and compression of fluids.

That the author (head, dep't of mech. eng., U. of Iowa) knows well the principles of teaching is perhaps best evidenced by his placing at the beginning of the book the two chapters on definitions and units and on dimensional analysis, as previously mentioned. Moreover throughout the book many examples are explicitly worked out, and at the end of the various chapters new problems are given for solution by the student. Periodical literature references are cited throughout the text, and references to books for parallel study are added at the ends of the chapters. A highly commendable feature of the book is that it is quite up to date on all the topics in which active research is still going on. This should make it especially valuable to the research worker who is usually worried as to whether the handbook data are still to be considered valid or whether they have been superseded by the results of recent and improved research investigations.

Students should appreciate the work of Prof. Croft in providing them such an excellent text, and practicing engineers will find it equally useful as a unified treatment of both the classical part of engineering thermodynamics and the empirical advances in the subject that have been brought up to the very date of the writing of the book.

—MORRIS MUSKAT, *Physics Dep't, Gulf Research & Development Corp., Pittsburgh, Pa.* (2)

History of Orifice Meters and the Calibration, Construction and Operation of Orifices for Metering. Report of the Joint A.G.A.-A.S.M.E. Committee on Orifice Coefficients. American Society of Mechanical Engineers, New York, 1937. Paper, 8 × 10½ inches, 64 pages. Price $2.75.

The length of the title will no doubt prevent this little book from enjoying the wide sale which it deserves. Another handicap is that, except for the stiff-paper cover, it has been produced by the offset process from typewritten originals—and this is really regrettable because, while few persons object to the use of typewriter type in an 8-page bulletin, many will dislike the idea of having to read that kind of matter for hours. This reviewer has had to read this book two or three pages at a time, with a day or a week intervening between these samplings. Therefore, no attempt will be made to report on the literary style, effectiveness of arrangement, etc. After all, these things are secondary. The main purpose of this book is to present data —mostly numerical data—and it is a pleasure to testify that this purpose has been accomplished to an extent that will benefit not only the gas industry but in general the users of orifice meters for gases and liquids.

It all began right here in Pittsburgh, in 1931, when the American Gas Association and the A.S.M.E. appointed a joint committee to study existing data on orifice meters, and to make recommendations for the construction and installation of pipe orifices and constants for use with them which would permit "the metering of all fluids with a maximum commercial accuracy" and with consistent results with "all types of orifices and pressure taps in common use." This book reports the results of these investigations. It contains:

An outline of the history of the orifice meter in this country; a short résumé of the various researches conducted by the committees and other interested bodies; An analysis of the data available; Recommendations on the proper methods of constructing and installing concentric orifices; A general discussion of the precautions to be observed in the use of orifices as metering devices, and the accuracy to be expected; Information on effect of pulsating flow on measurements by an orifice; Tables and curves of orifice coefficients.

In short, this Report is not only based on, but *presents most of the available data* (deemed to be of merit) from tests of orifice meters made in the United States during recent years. As such, it will be of considerable value and assistance to anyone interested in measuring rates of flow of gases *and liquids*.

All honor to the Joint Committee! Here are their names: *Chairman*, T. H. Kerr; *members (and alternates)*, H. S. Bean, J. R. Carlton, G. D. Conlee (died after completion of work and just before issuance of this book), R. J. S. Pigott, C. C. Reed, R. E. Sprenkle, A. E. Young.

As often happens when a committee decides to include a history of recent progress in a certain field, some persons not on the committee find that their contributions to that field received inadequate mention (or were not even mentioned). Pasted inside the cover of my copy of this Report is a memorandum which I wrote at the request of a man whose engineering genius I admire—which I wrote as he dictated it. The gist is that the Report not only fails to credit him with certain contributions but in one instance credits someone (another non-member) for something done in 1932 which my informant did in the 'twenties and published in 1929. I promised him that I would mention the possibility that the historical parts might stand correction. I am fulfilling this promise — made a few weeks after I received the Report, several months ago. Since then I have had more leisure to peruse this hard-to-read pamphlet, as well as my informant's 1929 disclosure and the other worker's 1932 disclosure. I'm mighty glad I didn't promise to name either of these earnest workers, because the questions of priority herein involved are almost like the "audion tube" or "oscillator" or "feed-back" *cause célèbre*: after twenty years of lawsuits the Supreme Court in 1934 declared that deForest was the *inventor* but some radio pioneers maintain that Armstrong was the *discoverer*.

The Joint Committee had a tough and thankless job. Their Report derives an equation (of importance to meter users striving for highest accuracy) and states that it is identical with the 1932 disclosure. Anybody who has taken algebra can see this *identity*. Anybody who has taken thermodynamics can see a *similarity* with the 1929 disclosure. To determine the degree of similarity, deduce the degree of debt and adjudicate the priority, however, is a job for real experts. That lets me out!

—M. F. BEHAR (2.05)

Regeln für Wassermengen-Messungen bei Abnahme von Wasserkraftmaschinen. (Standards for Measuring Water in Acceptance Tests of Water Power Engines). VDI-Verlag, Berlin, 1936. Paper, 8¼ × 11⅝ inches, 12 pages. Price 2 RM (1.50 RM in U.S.A).

As the title of this pamphlet implies, it is a description of methods to be used for measuring water in acceptance tests of water power devices. The use of current meters is described in considerable detail, including the requirements for the meter, the metering locations in open channels and in closed lines, time measurement, evaluation of the test data, and accuracy. Measurement by means of sharp-crested weirs receives similar attention. Less attention is given to other metering methods —Pitot tubes, nozzles, orifices, Venturi tubes and Venturi channels, filtration methods, Allen salt velocity method, Gibson method, weirs with end contractions or other shapes, and holder and weight measurements. These latter methods are to be used only upon agreement between the interested parties, and it is recommended that two of them be used, one checking the other.

An extensive bibliography is given, and it is recommended that the literature be consulted for further details in connection with the latter-named testing methods. For testing with current meters and sharp-crested weirs, however, the data is sufficient to permit the setting-up and operation of the apparatus without reference to any further information.

This publication is one of a series of standards and methods published by the Verein deutscher Ingenieure; its origin is a good recommendation for its reliability.

—LYMAN M. VAN DER PYL, *Chief Chemist, Pittsburgh Equitable Meter Co., Pittsburgh, Pa.* (2.05)

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